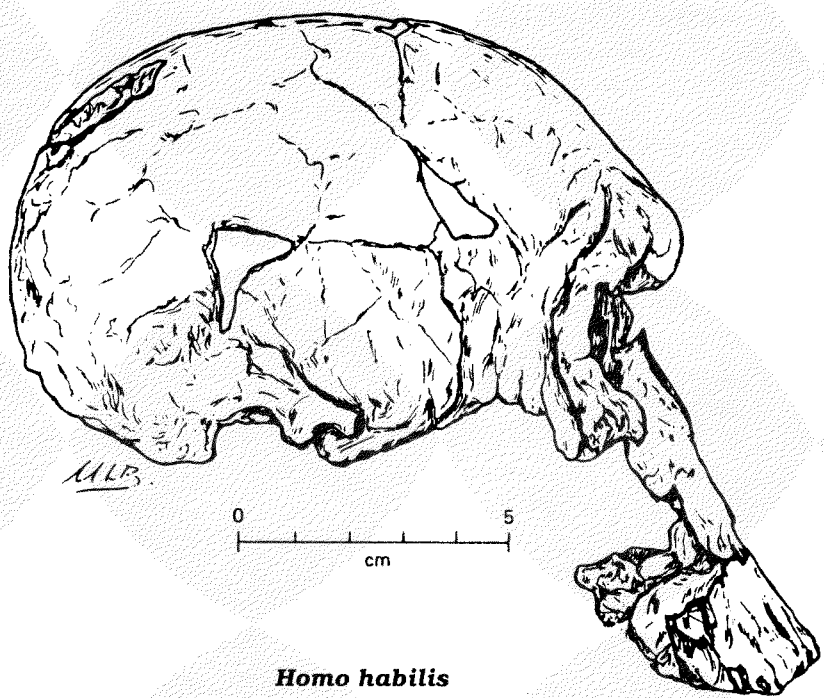
Creation / Evolution



Homo habilis

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About this issue . . .

"Scientific" creationists are especially concerned with human evolution. *Creation/Evolution* has dealt with the topic often, but this issue is particularly dedicated to the subject and the ways anti-evolutionists have misinterpreted it. Our authors address some of the most common creationist claims about the major fossil hominids—the australopithecines (and *Homo habilis*), pithecanthropines (*Homo erectus*), and Neandertals. (Modern convention tends to eliminate the "h" from *Neanderthal*.)

Also included is an article on an aspect of chemical evolution and the reproduction of DNA molecules. Future issues will deal with other aspects of molecular evolution. Creationist field research, more dinosauriana, transitional fossils, and the misuse of biblical literalism are also forthcoming, along with some of the backlog of book and film reviews we have accumulated.

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Cover illustration: Drawing of Richard Leakey's *Homo habilis* skull ER 1470 by M. L. Brace, from C. L. Brace et al., 1979, p. 54.

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Creationists and the Australopithecines

Martin K. Nickels

Introduction

The existence of fossils in sequential geological deposits poses serious problems for creationists who do not acknowledge evolutionary patterns in the paleontological record. *Archaeopteryx*, the transitional reptile-bird form, is one of the most outstanding examples of a major evolutionary transition, and the fossil sequences for horses (Monroe, 1985), elephants, and even horned dinosaurs (Edwords, 1982) are examples of well-documented evolutionary lineages. However, the fossil evidence pertaining to human evolution and the origin of the hominids in general presents special difficulties for creationists.

Australopithecine fossils provide an especially good example of two of the creationists' central concerns: the obvious biological similarity between humans and other organisms (particularly the apes) and the existence of creatures with a distinctive (perhaps disturbing or distressing to creationists) combination of apelike and humanlike features. Creationist claims to the contrary, the hominid status of the australopithecines is quite justified, not seriously open to question today, and of special importance to the question of the evolutionary origin of humans.

Furthermore, even though I shall emphasize the physical similarities between the australopithecines and later hominid forms, it is important to understand that their taxonomic classification as hominids is based not merely upon physical similarities but upon their inferred *evolutionary* affinities with later hominids as well. Because of the evolutionary perspective of modern biology and systematics (Eckhardt, 1979; Wolpoff, 1980), the inclusion of the autralopithecines in the family Hominidae is based upon the fact that they are in the right geographical

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place (Africa) at the right time (after the earlier Miocene dryopithecines and ramapithecines and before the later *Homo erectus*) as well as upon their degree of structural similarity to *Homo erectus* and *Homo sapiens*.

An objection may be raised that the inherent evolutionary perspective of modern taxonomic classification provides an a priori basis for creationists to criticize and reject outright the conclusion that the australopithecines are hominids and the evolutionary significance of this fact. After all, creationists might argue, since any such evolutionary-biased classification of these fossils is based upon the two fundamental errors that undermine all modern biology, if not most of science—namely, the great antiquity of the world and the evolutionary development of all the life forms on this planet—then the classification is meaningless. Furthermore, since modern geological dating methods are supposedly faulty, as "young-earthers" allege, and there is no compelling fossil data to support the claims of evolutionary kinship between any organisms (it's all those gaps, you know), then the australopithecines can hardly be considered convincing evidence of any long-past human evolutionary ancestors because no such ancestral forms can even exist. Thus, creationists could conclude that they need not even concern themselves with any discussion of the australopitheci es; at best, it is all a big mistake, or, at worst, merely another effort to deny and obscure the *real* story of the origin of humans and the world.

Dismissing the evidence or misinterpreting it, however, does not answer the question of what the australopithecines are. Their geological antiquity aside, and simply from the perspective of comparative anatomy, the combination of features evident in the australopithecines would present significant problems for creationists even if there were no evolutionary interpretations of their status. We can only wonder how Carolus Linneaus, the eighteenth-century "father" of modern taxonomy and a believer in special creation, would have classified the australopithecines when he only reluctantly excluded the "ape" from the genus *Homo*, even though he acknowledged his inability to find a "character" to justify any separation of the two (Green, 1959:184–185).

Consider the creationists' dilemma: the more humanlike the australopithecines are, the more difficult it is to maintain the special uniqueness of "man." On the other hand, the more apelike the australopithecines are, the more apelike modern humans are (because of the array of attributes we share with the australopithecines) and, again, the less unique and less special is "man." From either perspective, the australopithecines make trouble for creationists.

Davis A. Young, an acknowledged biblically based scholar believing in the special creation of humans (in the form of Adam and Eve), has considered some of the problems posed by fossil evidence of human evolution for certain Christian beliefs (Young, 1977, 1982a, 1982b). His thoughtful discussion of the hominid fossil record is in sharp contrast to that of the three creationist authors considered here. (Two of Young's books, *Creation and the Flood* and *Christianity and the*

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Age of the Earth, also happen to be two of the most severe, scholarly, and insightful critiques of the young earth model of "scientific creationism" yet published.) The questions about the meaning of the human fossil evidence that he raises reveal some of the difficulties facing creationists:

> What is the Bible-believing scientist to do with these [australopithecine to Neanderthal] fossils? Can he tell where in time among this group of fossils the creation of Adam took place? Can he tell which of these ancient manlike fossils represent genuine man? [1977:151]

In a May 1982 article in *Eternity*, Young acknowledges the possibility of a human evolutionary sequence extending back to the australopithecines but nevertheless concludes:

> The biblical record clearly demands the special intervention of God in the origin of man. . . . Evolution cannot account for man as God's image-bearer, nor can it account for our sinful estate. It seems to me that the present scientific theory of evolution, *apart from the question of the origin of man*, is not necessarily anti-Christian or unbiblical. [1982b:19; emphasis added]

Although not the topic of this paper, the theological and biblical problems raised by the evidence for the evolutionary origin of humans is of the utmost importance for many thoughtful people.

Taxonomic Terminology

Nonspecialists may easily be confused by the way such names as australopithecine, *Australopithecus*, hominid, Hominidae, pongid, Pongidae, *Homo*, and even human are used by various authors. It is necessary to have some understanding of what these terms mean and how they are formally used (and misused) before considering some specific creationist writings on the australopithecines.

Since first introduced by Carolus Linnaeus in the 1700s, standard taxonomic practice has assigned a genus and a species designation to each distinctive organism studied. Examples are *Homo sapiens* for modern humans, *Pan troglodytes* for the common chimpanzee, *Pan paniscus* for the pgymy chimpanzee, *Gorilla gorilla* for the gorilla, and *Pongo pygmaeus* for the orangutan. Genus-level names are capitalized, species-level names are not, and both names are italicized or underlined in print.

Biological species are generally conceptualized as "groups of interbreeding

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natural populations that are reproductively isolated from other such groups" (Mayr, 1970:12). Occasional interbreeding between members of related, but different, species—such as lions with tigers or horses with zebras—does not invalidate the species concept in general nor the legitimacy of taxonomically distinguishing between the particular forms involved. This is because such infrequent mating is in contrast to the usual pattern of members of the same species mating only with others of the same species and because the "hybrid" almost never constitutes a natural population.

Species are also usually distinctive in terms of their anatomy, physiology, habitat, reproductive patterns, diet, geographical range, and other features. Physical differences are especially useful in classifying the millions of extinct species. Reproductive incompatibility is not always ascertainable, since dead specimens are no longer reproductively active!

Species that share more features in common with one another than they do with other species are grouped collectively into a common genus (for example, *Pan troglodytes* and *Pan paniscus* or *Homo sapiens, Homo erectus*, and *Homo habilis*). Genera (plural of *genus*) sharing features that serve to distinguish them from other genera are grouped into still broader categories such as families (for example, *Pan, Gorilla,* and *Pongo* in the family Pongidae; *Homo* and *Australopithecus* in the family Hominidae). The common terms *pongid* and *hominid* are used extensively to distinguish between characteristics of the great apes and those of modern humans and their fossil antecedents. For example, in an evolutionary perspective, hominid features of earlier forms (either genera or species) may be manifested more often in different or primitive fashion than they are in later forms. But it is the distinctive pattern of these features that is the basis for making the taxonomic distinctions between hominids and other organisms.

It is sometimes difficult to make decisions about taxonomic placement of living forms, and it can be even more difficult when dealing with fossil specimens. But problems in applying the principles of taxonomy no more invalidate the endeavor than do problems in accurately translating ancient Hebrew, Aramaic, and Greek documents invalidate the efforts of scholars to understand biblical texts. Scholarly disputes among specialists in both endeavors are to be expected and constitute a natural part of the process of achieving consensus judgments about particular problems.

Problems in Taxonomic and Nontaxonomic Usage

Neither *ape* nor *human* are formal taxonomic terms. While human traditionally refers to living and recent members of *Homo sapiens*, it becomes increasingly

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difficult to apply this term unequivocally to such forms as Neandertal, *Homo erectus, Homo habilis*, and the australopithecines. Human does *not* necessarily mean the same thing as *Homo* or hominid. In formal discussions of fossil specimens, it is probably best to minimize one's usage of this term in order to avoid leaving unjustified impressions in the reader's mind. A good example is the use of the term human when describing all of the different australopithecine forms, because this may well leave the reader with the idea that all of these forms are ancestral to modern humans when this is clearly not the case.

The genus name *Australopithecus* does not necessarily mean the same thing as the informal term *australopithecine*, frequently used in a collective sense to refer to all of the non-*Homo erectus* African hominid fossils of Pliocene and early Pleistocene age. When used in such a fashion, to some authors australopithecine actually refers to an evolutionary "grade" of features shared because of a common level of organization (Wolpoff, 1980:34, 131, and 180) or to a "clade" or groups of species having a single common ancestor (Jolly and Plog, 1982:83 and 193–194). In recent years, a new convention has emerged that simply entails using some variation of the phrase *Pliocene-Pleistocene hominids* to refer to these fossil forms (Eckhardt, 1979; Kennedy, 1980; Nelson and Jurmain, 1982; Poirier, 1981; Wolpoff, 1980).

How Many Fossils?

If knowledge of the number and nature of australopithecine fossil remains were based solely on creationist sources, then one might well be left with the impression that there are only a handful of fossils that have been discovered and that even these are not especially informative. Henry M. Morris exemplifies this impression succinctly: "In many cases (e.g., Ramapithecus, Australopithecus [*sic*], etc.) the very fragmentary evidence is quite consistent with the view that such creatures were merely extinct species of apes" (1978:46). Use of the term *fragmentary* here conveys the double impression that the fossils themselves are in broken condition (frequently, but not entirely, true) and that there are hardly even enough specimens to bother considering, let alone use as a basis for some wild and imaginary evolutionary schemes (not nearly the true state of affairs). Morris and Gary Parker reemphasize the plausibility of these fossil forms being apes: "The name *Australopithecus* means 'southern ape,' and there's a good chance that's just what they are" (1982:119).

Just how many of these fossils have been recovered to date? Let's look at the evidence.

In their 1982 physical anthropology textbook, Harry Nelson and Robert Jurmain tabulate the number of specimens. For the five South African sites alone

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there are some 175 cranial remains, 769 teeth, and 78 postcranial (from the neck down) remains for a total collection of 1,022 items representing some 121 to 157 individuals (1982:393). Elsewhere in their text, they tally data from the East African fossil localities in Tanzania, Ethiopia, and Kenya—a minimum of 475 specimens (teeth and bones) representing *at least* 100 to 200 individuals (1982: 430–431). Similar data can be found in Eckhardt (1979:460–467) and Kennedy (1980: chapter 7) and can be obtained from the numerous original scientific reports of field investigators. More specimens are always desirable (and, in fact, are being unearthed regularly), but it is evident that we are not dealing with a mere handful of fossils.

Pongid or Hominid?

To put it as bluntly as possible, exhaustive study and analysis of these hundreds of fossil specimens have resulted in one unequivocal conclusion: the australopithecines are *not* apes; they are hominids. But what exactly is the basis for this conclusion? What features does one examine in order to ascertain whether a given specimen (fossil or not) is a pongid or a hominid? Studies of present-day forms reveal some obvious, and not so obvious, differences between living representatives of these two groups. These differences can conveniently be grouped into three broad complexes: locomotion; face, teeth, and jaws; and brain size and function.

In terms of locomotion, pongids possess the anatomy for brachiation—swinging or hanging in the trees in a vertical position with the arms extended over the head. This anatomy is modifiable for extensive terrestrial locomotion (at least in the case of *Pan* and *Gorilla*) into the "knuckle-walking" pattern of semi-erectness. The occasional bipedalism exhibited by these forms does not contradict their fundamental brachiating anatomical attributes. Among these are longer arms than legs, naturally curved fingers with a short thumb, a narrow pelvis, and an opposable big toe to facilitate the grasping of branches. This brachiating anatomy and pattern of locomotion is in stark contrast to the fully erect bipedalism of modern *Homo* who possess longer legs than arms, a precision grip using effective opposable thumbs, a wide and shallow pelvis with broad iliac blades, expanded sacral and lumbar vertebral attachments to help support the erect upper body, a strong and supportive yet fully extendable knee joint, and a foot with strong arches and a nonopposable big toe for both powerful striding push-off and support of the entire body. Also, the more forward position of the *foramen magnum*, or large hole in the base of the skull, reflects the fully erect posture of humans in contrast to the more rearward position of this opening in pongid skulls; hominid skulls rest atop the vertebral column.

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With regard to the second complex—face, teeth, and jaws—living pongids have an obviously protruding lower face while human faces are essentially flat. The front teeth of the pongids are notable for having broad, forward-slanting incisors and fairly long, projecting canines. Modern humans have narrow, vertically implanted incisors and short canines. Whereas the back teeth of pongids are comparatively large and seldom worn down flat in a side-to-side fashion, smaller and flat-worn molars are characteristic of most pre-agricultural humans. The jaws of pongids are heavy and possess powerful chewing muscles frequently associated with prominent bony attachment sites such as the sagittal crest along the top of the skull. Humans have less powerful muscles and lack such powerful bony protrusions.

Finally, pongid brains are absolutely smaller than brains of modern humans (on the order of about one-third to just less than one-half) as well as being relatively smaller compared to overall body size.

Relying upon these (and many other) criteria to assess the taxonomic and evolutionary status of the australopithecines, scholars have reached the consensus view that they were definitely hominids, although not identical to modern humans. To quote Wolpoff:

> What is typically hominid is not necessarily the same as what is typically human today. Some features that have characterized most of hominid evolution do not appear in living people. . . . The first members of our lineage may be more *hominid-like* than their pongid contemporaries without necessarily being more *like living humans*. [1980:67]

The significant point to emphasize with regard to the australopithecines is that, while they are distinctive in certain respects, they exhibit the *combination* of features that distinguishes them from any known living or extinct pongid and that conforms to the fundamental pattern of features that is seen in later hominid forms.

Thus, despite some pongidlike features—such as molar tooth size, small absolute brain size (compared to *Homo erectus* and *Homo sapiens*), powerful chewing complex with occasional slight sagittal crests, and relatively large protruding faces—the australopithecines are still classified as hominids (but not as *Homo sapiens* or even *Homo erectus*) since they manifest the overall pattern characteristic of this taxonomic group.

Among the more important hominid attributes of the australopithecines are a large brain relative to overall body size, reduced canine size, flat-worn molars, and numerous indications of the adoption of fully erect posture and bipedalism (although not necessarily in a fashion identical to modern *Homo*). In addition to these characteristics, australopithecines share with other hominids a strengthened

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lower back, a pelvis with a broad ilium, and virtually all of the other pelvic, hip, knee, ankle, and foot modifications associated with erect bipedalism. These features and others are described and discussed in any number of anthropological works (for example, Howell, 1978; Jolly and Plog, 1982; Kennedy, 1980; Poirier, 1981; Wolpoff, 1980). The hominid status of the australopithecines has been so thoroughly substantiated by this time that a statement like that of Morris that they can be considered "merely extinct species of apes" (1978:46) suggests a profound ignorance of the wealth of data now available.

How Many Forms?

Paleoanthropologists today agree that more than one form of Pliocene-early Pleistocene hominid existed. While there is not universal agreement about the number of species (or even genera) recognized, there is widespread consensus that two basic forms are involved: the gracile and the robust, based upon overall size and degree of body and chewing musculature (*see,* Figures 1 and 2, center book). The robust forms are considered to be somewhat more specialized and less likely to be directly ancestral to later hominids like *Homo erectus*. The robust forms also appear to have consisted of an earlier and a later species. They are usually placed in the genus *Australopithecus* but may still occasionally be referred to as *Paranthropus*. The most common species designations are *Australopithecus robustus* and *Australopithecus boisei.* The fossil evidence for these robust species dates from about 2.6 to 1 million years ago (Boaz, 1979:76; Johanson and Edey, 1981:284; Shipman, 1986). Some of the earlier robust forms may or may not have been contemporaries with some of the gracile forms (usually designated *Australopithecus africanus*) depending upon one's assessment of the possible age of some specimens and sites, as well as the classification of some specimens. At least one interpretation considers the gracile forms as being ancestral to the robust forms (Wolpoff, 1980).

It does appear, however, that there existed a distinctly earlier, more primitive australopithecine form (more nearly gracile than robust in appearance) which is quite possibly ancestral to both the later gracile and robust species regardless of whether the later graciles are, in turn, ancestral to the robust forms. This earlier, more primitive australopithecine dates from approximately 4 to 3 million years ago and has been classified as *Australopithecus afarensis* by Donald Johanson and Timothy White (1979). This species includes fossils recovered from Hadar in Ethiopia and Laetoli in Tanzania. At least one dissenter does not think that all of the fossils Johanson and White have assigned to *Australopithecus afarensis* should be so assigned (Leakey, 1981:70). *Australopithecus afarensis* is characterized by its erect and bipedal form of knee and pelvis and a distinctly pongidlike

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skull.

The final form to be considered is *Homo habilis.* Generally accepted specimens assigned to this earliest species of our own genus date from around 2.1 to 1.5 million years ago. Our understanding of the evolutionary relationship existing between *Homo habilis* and both the gracile and robust australopithecines is incomplete. While all of the most widely accepted *Homo habilis* fossils are contemporaneous with many earlier robust australopithecines (and, thus, evolutionary "cousins"), the relationship between *Homo habilis* and the gracile form is less clear. While *Homo habilis* resembles the gracile form somewhat in terms of overall body size and musculature, it tends to have a larger braincase and may have had a slightly different form of bipedal locomotion (Jolly and Plog, 1982:220; Kennedy 1980:243). *Homo habilis* is usually considered descended from some earlier australopithecine form, most likely *Australopithecus afarensis* ultimately but from *Australopithecus africanus* as an intermediate link (Johanson and Edey, 1981:284; Jolly and Plog, 1982:189, 207, 209; Wolpoff, 1980:155, 165, 181–182). *Homo habilis*, in turn, is considered the most likely ancestor of *Homo erectus* who appears around 1.5 million years ago near Lake Turkana in Kenya. *Homo erectus* coexisted with the last of the surviving robust australopithecines, which disappear from the fossil record at around 1 million years ago. There is no apparent evidence of either *Homo habilis* or gracile *Australopithecus* coexisting with *Homo erectus.*

Creationist Criticisms of the Australopithecines

With this brief background, let us now turn to some additional creationist writings dealing with the australopithecines. The claims of Morris (1978) and Morris and Parker (1982) that the australopithecines may be nothing more than apes have already been discussed. Consider now this statement from Robert Kofahl's *Handy Dandy Evolution Refuter:* "*Australopithecus* has now gone completely down the drain as far as human ancestry is concerned" (1980:78).

The first difficulty the reader should have with this assertion, of course, is that it is not at all clear to which forms Kofahl is referring. If he is referring to the robust and later gracile forms, he is in technical agreement with the majority of paleoanthropologists, at least in the sense of either of these forms being *directly* ancestral to the genus *Homo.* But what Kofahl does not say is that many (if not most) paleoanthropologists think that the earliest species of the genus *Homo* now usually recognized, *Homo habilis*, is quite likely descended from some form of gracile *Australopithecus* earlier than 2.5 million years ago. The most likely candidate, as already mentioned, is *Australopithecus afarensis.* Thus, Kofahl is, at

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best, premature and probably quite incorrect in dismissing *Australopithecus* from the ancestry of the genus *Homo* and, subsequently, modern humans. He falls into the "missing link" trap, assuming that an individual fossil is *the* transitional form; such reasoning would require one to rule oneself out of the hominid line if a great-grandparent were unknown despite a clear family tree filled with great-aunts, great-uncles, grandparents, parents, uncles, aunts, and cousins.

Presumably to show that the allegedly older and ancestral *Australopithecus* is actually younger than its supposed descendants, Kofahl makes reference to both "a find which was more human and . . . dated a million years older" than *Australopithecus* and "evidence of a human living area [at Olduvai Gorge] at a lower level than the *Australopithecus* remains" (1980:77). The first reference is to the KNM-ER-1470 cranium found by Richard Leakey's team near Lake Turkana and classified as *Homo habilis*. The second reference is to the Leakeys' Olduvai Gorge discovery of site DK1, an apparent campsite with evidence of artificially placed heavy stones similar to stones used until recent times by hunter-gatherers to weigh down the edges of animal skin shelter tents or windbreaks. The structure and tools there have been attributed to *Homo habilis*, bones of which have been found at sites in the gorge nearby. Kofahl does not mention or discuss the *Homo habilis* taxon, so one can only wonder if his use of the term *human* here refers to this early species of *Homo*. (In any case, the "million years older" age assigned to the 1470 specimen has been revised downward to approximately 2 million years, contemporaneous with the Olduvai Gorge specimens of this species.)

Given that *Homo habilis* had already been rather extensively documented by the time Kofahl wrote (1977 and 1980), his failure to include any formal discussion of it in his treatment of the australopithecines is surprising, to say the least. By ignoring it, of course, he need not inform his readers that this form is usually considered ancestral to later species of *Homo*. Consequently, his rhetorical question, "Now who will step up to be the next candidate [for human ancestry]?" (1980:78) rings hollow. His less than technical reference to *Australopithecus* having "gone completely down the drain as far as human ancestry is concerned," implying the total irrelevance of this genus or grade foh our understanding of human evolutionary origins, is disingenuous. Our understanding of the origin of the genus *Homo* in particular and the family Hominidae in general would not have been possible without knowledge of the nature and variation in the genus *Australopithecus*.

But Kofahl is not done with his discussion of Pliocene hominids. Elsewhere he writes: "Both [Richard] Leaky [*sic*] and the Taieb-Johanson team have claimed that their fossil finds make all previous theories of human evolution obsolete, but they have little to offer as substitute theories" (1980:78-79). Such a statement not only does gross injustice to the work of these scholars, it also indicates a profound misunderstanding or misreading of their writings. The fact that this 1980 edition of Kofahl's 1977 work includes references only to 1971 and 1973

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articles by Leakey and two news accounts of Taieb's and Johanson's work published in 1974 and 1976 reinforces the conclusion that Kofahl was, at best, ignorant of the numerous published materials that already dealt with these discoveries even by 1977, let alone 1980. Kofahl's claim that evolutionists have "little to offer as substitute theories" is ludicrous. Competing interpretations are numerous—a sign of a healthy science—but even the most skeptical analysts of the swarm of australopithecine-habiline fossils grant that directly or indirectly these fossils represent the first hominids.

But what is Kofahl's basis for claiming that *Australopithecus* has disappeared down the drain of human ancestry in the first place? In the writings of Kofahl and in Morris and Parker (1982:121-124), the work of Charles E. Oxnard is cited. Let's examine what Oxnard has said and then consider how, in particular, Morris and Parker seriously misquote him.

Charles Oxnard is an anatomist who has utilized various statistical techniques to analyze and compare the form and function of bones from both fossil and living species. The results of his work that are pertinent to this discussion are those regarding the evolutionary status of the australopithecines. Succinctly put, he does not think that the australopithecines are in the evolutionary lineage leading directly to the appearance of *Homo erectus* and *Homo sapiens.* (He also does not think that *Homo habilis* is a valid taxonomic category.) His analyses were based upon selected fossil specimens, including a pelvis and scapula from Sterkfontein, a talus (large ankle bone) from Kromdraai, and four specimens from Olduvai Gorge: a clavicle, talus, proximal hand phalanx, and terminal toe phalanx.

His studies suggest to him that most of these australopithecine specimens are uniquely different from both living apes (and in some cases the Miocene-age ape form *Proconsul*) and modern humans (Oxnard, 1973:165, 168; 1979:273–274). After concluding that "both of these regions [hindlimb and forelimb] present clear evidence of functions that differ from those of modern man" (1973:168), Oxnard goes on to state that "we may now be able to search for the actual nature of morphologies and functions relating to a species that is becoming somewhat similar to man, but that is clearly not there yet" (1973:168). In his 1979 article, cited by Morris and Parker, Oxnard writes, "It is far more likely that the genus *Homo* is much older than currently believed and that the australopithecines of Olduvai and Sterkfontein represent only parallel evolutionary remnants" (1979:274). Both this quote and the second one, cited from his 1973 work, clearly reveal Oxnard's acceptance of the reality of human evolution, but Morris and Parker are not interested in Oxnard's evolutionary perspective; they emphasize instead his rejection of the australopithecines from the mainstream of modern human ancestry. They write about Oxnard's findings:

> Viewed one way, for example, the pelvic bones of australopithecines seem to be intermediate between man and ape. But merely viewing

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> the bones from a different angle makes the specimen seem as far distant from man as the apes are. "Yet another view," says Oxnard, "might suggest that the fossil arose from the African apes via modern humans!"—in other words, that humans were the missing link between the australopithecines and the apes! [1982:122]

Not only do these authors erroneously reference the word *fossil* to the phrase "the pelvic bones of australopithecines" when Oxnard's own reference is to the single Olduvai toe bone, but they omit a crucial part of Oxnard's orginial statement, which read: "Yet another view *if assessed naively* might suggest that the fossil arose from the African apes via modern humans!" (1979:268; emphasis added). The words *if assessed naively* were not quoted by Morris and Parker, and this omission leaves the unwary reader with the idea that Oxnard actually thinks such a view is tenable when he clearly does not.

Furthermore, before too much is made of the fact that Oxnard also found that the australopithecine fossils he studied occasionally show more similarities to the orangutan than to other pongid or hominid forms, be assured that he does *not* conclude that these fossils represent orangutan ancestors! To quote: "This does not mean, of course, that the fossils are related in any genetic way to the orangutan" (1979:273–274). Oxnard's basic position is that the australopithecines were in certain ways unique in their locomotor functions. He thinks that they were bipedal (or, at least, partly so) in a distinctly nonpongid way (1973:165).

What are we to make of Oxnard's 1973 studies? His conclusion that the australopithecines were different from modern humans does not contradict the view held by paleoanthropologists. After all, given an evolutionary perspective, it is to be expected that some of the earliest representatives of the Hominidae were different from the only surviving form today. Keep in mind that he certainly does not conclude that the australopithecines were pongids; rather, he thinks that they were a parallel line of hominid evolution with an earlier common ancestor. It is also important to realize that Oxnard's work has not gone uncritiqued. In the first place, he used only a handful of the fossil materials available for his study. He did not (and to my knowledge still has not) studied any of the specimens from Lake Turkana, Hadar, or Laetoli from which we now have several postcranial specimens that should be considered. One reviewer of his 1973 book noted, among other things, the small sample size Oxnard employed, the "unusual way" that some pelvic measurements were taken that appeared to bias the results, the incompleteness of the Sterkfontein scapula used, and the fact that Oxnard does not mention that the Olduvai talus he did use comes from a virtually complete fossil foot: "This is unfortunate because many claim that this foot is the best evidence there is proving the human affinities of the australopithecines" (McHenry, 1975:988). It should be stressed that Oxnard disagreed with a particular interpretation of australopithecines—not with basic evolutionary views of australo-

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piths (Godfrey in Cole, 1981).

There have also been numerous other studies whose conclusions are at variance with those of Oxnard. One of the principal investigators of australopithecine locomotor patterns is C. Owen Lovejoy. His conclusions about the nature of their bipedalism are especially interesting to contrast to Oxnard's. For example: "It is my opinion that not only are these capabilities [of bipedal walking] clearly in evidence, but that there are, in fact, significant indications that this extinct biped might have been superior to modern man" (1974:151). Lovejoy thinks that the australopithecines were indeed different from modern humans, just as Oxnard concluded, but in an unexpected fashion. On the other hand, Lovejoy writes:

> More often than not, the form of the pelvis in *Australopithecus* has been considered unique—clearly differentiated from that of *H. sapiens*. This is not necessarily the case, as pelvic form in modern man is highly variable, especially with regard to those features which appear to separate *H. sapiens* and *Australopithecus*. [1974:159]

As in Oxnard's case, Lovejoy's conclusions were based upon a sample that did not include specimens from Lake Turkana, Hadar, or Laetoli. But subsequent analysis of several postcranial specimens from Hadar have only reinforced Lovejoy's opinion about the efficiency of the australopithecine pattern of erect bipedalism (Johanson and Edey, 1981:329). Other investigators in this area do not necessarily agree with Lovejoy about the superior efficiency of australopithecine bipedalism, but there is essentially universal agreement that these hominids were clearly erect bipeds (*see*, for example, the 1979 review article by McHenry and Termerin on the fossil evidence for hominid bipedalism and Gomberg et al., 1984, for divergent views).

Conclusion

There is no doubt about how australopithecines are perceived by paleoanthropologists and evolutionary biologists today. Recognized as early, if not the earliest, hominids, they exhibit some novel adaptations that subsequently led to the evolutionary appearance of the genus *Homo* and eventually our own species *Homo sapiens*. Given this view, it might be natural to regard these creatures as the popular "missing link" in the human evolutionary sequence. Such a conclusion, however, is not really consistent with our modern conception of the nature of organic evolution. The notion of a "missing link" frequently connotes the erroneous idea that earlier forms existed almost solely to evolve into some later

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form. This idea, in turn, is related to the idea of orthogenesis or the notion that evolutionary developments are inevitable and the result of some preestablished goal or aim. Modern evolutionary biological thinking does not accept such an idea as valid.

With specific reference to the australopithecines, Jolly and Plog reflect our current efforts to better understand these creatures:

> The features that *Australopithecus* shares with *Homo sapiens* are important in that they show us that the genus is hominid, a close relative of *Homo sapiens*. But they are important for another reason as well. They are part of the total adaptive pattern of *Australopithecus* —the features that these early hominids developed as they became distinct from their apelike ancestors. [1982:194]

How creationists will continue to deny and reject the taxonomic and evolutionary status of these forms remains to be seen, but surely they will continue to do so. There will be misunderstandings and distortions of both the fossil evidence and the opinions of evolutionary scholars. If the pattern of recent years is any indication of the future, new discoveries will undoubtedly answer some of our current questions, clarify our present understanding, and provide us with new puzzles about the australopithecines.

One question that will surely continue unanswered for quite some time, however, is the one posed by Davis A. Young: "Could Adam have been a creature like *Australopithecus*?" (1977:153). Now, that is some question!

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Creationists and the Pithecanthropines

C. Loring Brace

The Middle Pleistocene stretch of time—what I have called the "Pithecanthropine Stage" of human evolution (Brace, 1979)—is a fascinating period to anthropologists and is of interest here for two main reasons. First, the pithecanthropines represent a splendid characterization of life forms that are evolutionarily intermediate between apes and humans; and, second, the pithecanthropines have brought forth pronouncements from creationists that are so blatantly contrary to fact that some kind of public effort is necessary simply to set the record straight.

For that million-year stretch of time between about 1.5 million and 500,000 years ago, the only kind of hominid for which we have any evidence is a form that most anthropologists now refer to as *Homo erectus*. The first such specimen was discovered in Java nearly a century ago by Dutch physician and anatomist Eugene Dubois who labeled it *Pithecanthropus erectus.* Modern appraisers usually do not feel that it is distinct enough from *Homo* to warrant a separate generic name, but Dubois' species *erectus* is accepted by nearly all.

One "modern" appraiser who has rejected Dubois' initial claims and more recent assessments of his Java finds is Duane Gish. Curiously, in this matter he is not supported by the director of his own institute, Dr. Henry Morris, who declared that "*Homo erectus* was a true man, but somewhat degenerate in size and culture" (Morris, 1974:174). In contrast, Dr. Gish has concluded, "We believe that the claim for a man-like status for *Pithecanthropus* should be laid to rest" (Gish, 1979:127). The dilemma of the creationists, of course, is the fact that their own preconceptions require them to categorize something as either ape or human. When they actually encounter a creature that is in between, then they

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have to throw it in one or the other of the modern categories, and it is not surprising that a form with genuinely intermediate features should be randomly assigned to each of the only possibilities they will accept. From the point of view of their own logic, they are both equally correct. From an examination of the actual evidence, they are both demonstrably wrong.

It should be instructive to spend a moment and find out *why* Gish has reached the conclusion of his choice. There are two ostensible reasons. First, he raises a matter which he claims illustrates why Dubois' own findings are not to be believed. Toward this end he states, "Dubois concealed the fact that he also discovered at nearby Wadjak and at approximately the same level two human skulls (known as the Wadjak skulls) with a cranial capacity . . . somewhat above the present average" (Gish, 1979:124–125). He suggests that Dubois withheld publication until 1922 since otherwise his "Java Man" would not have been accepted as a "missing link." The same point is made by a number of other opponents of evolution, one of whom suggests that Dubois' action amounted to "a practical confession of fraud" (Kofahl and Segraves, 1975:127). As Gish has noted, "His failure to reveal this find to the scientific world at the same time he exhibited the *Pithecanthropus* bones can only be labelled as an act of dishonesty" (Gish, 1979: 125).

To put the matter straight, "nearby Wadjak" is a good one hundred miles of mountainous countryside away from Trinil, the site of Dubois' *Pithecanthropus.* Nor is it accurate to call them "approximately the same level" when one is well over half a million years old and the other is less than ten thousand. Finally, Dubois did publish preliminary accounts of his Wadjak material in 1889 and 1890 before his Trinil discoveries were even made, and he recapitulated these in print in 1892 before becoming involved in what he correctly realized was the far more significant *Pithecanthropus* issue. If there is a question of honesty involved, it has nothing to do with Dubois.

The second reason why Gish has questioned the status of Dubois' discovery has to do with anatomical assessment. Relying upon the appraisal published by Boule and Vallois in the third edition of their venerable tome, *Fossil Men*, Gish repeatedly refers to the Trinil skull as apelike and notes that if only the skull and teeth had been found the creature would have been regarded as closely allied to, if not identical with, the Anthropoids (Gish, 1979:126). In regard to the dentition, Gish has stated that "Every characteristic of these teeth given by Boule and Vallois is simian rather than man-like" (Gish, 1979:126). One should realize, however, that the "every characteristic" in Gish's phrase only refers to those characteristics that *were* simian and not to the many which they discuss that were not. Boule and Vallois sum up their appraisal of the teeth, noting, "All these facts provide singularly unambiguous confirmation of those that emerged from a study of the cranium" (Boule and Vallois, 1957:122). Now then, what was it that they actually concluded from a study of the cranium? Not what Gish has claimed at

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all. In their words, "In its principal characters, the Trinil skull-cap is really intermediate between that of an ape, like the chimpanzee, and that of a man of really low status, such as Neandertal man" (Boule and Vallois, 1957:118).

This is the full development of their appraisal of Dubois' famous *Pithecanthropus*; it is graphically illustrated in the photograph in their book (1957:119, fig. 75); and it is what most anthropologists now accept. In this photograph, the figure on the left is a chimpanzee skull and that on the right is the skull of a Neandertal of about fifty thousand years ago. In the middle, and obviously half way between in form and dimensions, is the original *Pithecanthropus*.

Now if the creationists have been less than reliable in their appraisal of the first of the Middle Pleistocene hominids discovered, their treatment of the most extensive collection of evidence—that found in China from the late 1920s through the 1930s—is even more bizarre. Their writings display a trail of distortions, personal innuendos, and outright falsehoods that have no faint kinship with anything that can be called science. Gish, for example, has gone on record as saying, "A close examination of the reports related to Peking Man, however, reveal a tangled web of contradictions [and] highly subjective treatment of the data" (Gish, 1979:127). Gish intends this statement to apply to those who did the original work in China, but, as we shall see, it is a description only of his own writing and that of a few others whose primary commitment is to sectarian religious dogma rather than to verifiable reality.

Let us, then, look at the facts of the matter and compare them with what has been said about them. The discovery of a few hominid molar teeth in Middle Pleistocene cave deposits at Choukoutien, just under fifty kilometers southwest of Beijing, stimulated Dr. Davidson Black, a Canadian-born professor of anatomy at Peking Union Medical College, to declare that they were evidence for the presence of a prehistoric population which he labeled, in splended polysyllabic Latin, *Sinanthropus pekinensis* (Black, 1927). This led to systematic excavation of the deposits at Choukoutien. Two years later, in 1929, the field season was rewarded by the discovery of a complete and undistorted skull of Black's *Sinanthropus*. Since this presented a fine mixture of human and anthropoid apelike features, Black felt that his earlier prediction and naming of a new type of hominid fossil had been perfectly justified. After careful consideration of his evidence and the subsequent discoveries at Choukoutien over the next seven years, anthropologists have concluded that Black's work was a model of scientific application but that the new name was not warranted.

The temptation to give dramatic fossil discoveries new and different names is an occupational hazard to which many a fossil finder has succumbed. Just within the past few years, we have had some modern examples of this in the highly publicized clash between Richard Leakey and Donald Johanson. But it does not mean that there is necessarily any doubt concerning the nature or even the significance of the material being discussed. It is often just a matter of what we decide to call

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it. Names are given by people for their own convenience, and, if different scholars do not agree upon what to call a particular find, this does not mean that they are not talking about the same thing or that there is anything wrong with their descriptions.

Immediately after the discovery of the Choukoutien skull in 1929, Davidson Black telegraphed the head of the Institute of Human Paleontology in Paris, Marcellin Boule, to give him a synopsis of the discovery. He also sent photographs, measurements, and a preliminary descriptive account along with his interpretation. Boule then used this as the basis of his own report to the readership of the French journal, *L'Anthropologie*. The only difference between what the two concluded was the fact that Boule felt that, in spite of a series of less primitive features, the fossil belonged in the same category as Dubois' *Pithecanthropus* while Black felt that it deserved his new genus and species name. History has sided with Boule and even gone one step further. Both the Chinese and the Javanese specimens are now regarded as belonging to the same species, *erectus*, and their genus is accepted as being the one that includes modern human beings, *Homo*.

The fact that Boule did not agree with Black on the new name and that most subsequent scholars have agreed with Boule has led Gish to accuse black of coloring "the facts to fit his scheme" (Gish, 1979:136). Gish then continues with the completely gratuitous slur, "What confidence can we have, therefore, in any of the descriptions or models of *Sinanthropus* from the hand of Dr. Black?" (Gish, 1979:136). I shall later demonstrate why it is that this accusation is without foundation.

In 1934, Davidson Black died suddenly after his preliminary publications had appeared, and his place was taken by Franz Weidenreich, a refugee from Hitler's Germany, who produced the definitive monographs on the fossils found at Choukoutien. These were not done without a hitch, however, because the Japanese invasion of China forced Weidenreich to flee to America before his work was finished. He took his photographs, notes, measurements, and a well-made series of casts, but he left the original fossils in Beijing. Later, these, too, were slated to be sent to America for safe-keeping, but the day they reached the Chinese port of embarkation was December 7, 1941, the day the bombs fell on Pearl Harbor. The ship on which they were to be sent was sunk, and the American marine detachment, in whose luggage they were being carried, was captured by Japanese soldiers. The fossils have never been seen since.

Fortunately, we still have the admirable publications of Black (1931; Black et al., 1934) and Weidenreich (1936, 1937, 1941, 1943) and the casts and models prepared under Weidenreich's direction. We can regret the loss of the originals, but the information which they represented is now the property of all who can read. This, however, is repeatedly denied by Gish, who directs the same kind of accusations toward Weidenreich that he earlier had made toward Black. A

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healthy skepticism is a necessary part of scientific practice, but, when it goes to the extent of alleging fabrication on the part of particular investigators, it should be backed up by unimpeachable evidence. In the present instance, as we shall see, this is just not the case.

Gish does concede that, if Weidenreich's work is accepted as presented, then the Choukoutien material would indeed qualify as a legitimate intermediate between ape and human status. "If one accepts uncritically Weidenrich's model of *Sinanthropus* as a true portrayal of the real *Sinanthropus*, then he could hardly reject the . . . appraisal . . . that *Sinanthropus* occupies a position intermediate between anthropoid apes and man" (Gish, 1979:137).

The merits of this assessment can easily be seen as you contemplate the illustration which appears in the final volume of Weidenreich's masterly treatment of the Choukoutien material (Figure 3). Here his reconstruction of a *Sinanthropus* specimen appears between the skull of a female gorilla and the skull of a modern north Chinese male. It is visually obvious that the size of the *Sinanthropus* brain case is just half way between, and the measurements that are recorded in Weidenreich's monograph amply confirm what the eye tells us. The jaws and teeth also fall between, although closer to the modern human side, and, if one were to take such crucial diagnostic features as canine tooth projection into account, they would be considered entirely human if notably primitive. But since Gish's preconceptions will not allow him to accept the possibility of an intermediate position for *Sinanthropus*, he does his best to render it unlikely. This he does, not by a consideration of the evidence itself, but by an attempt to impugn Weidenreich's integrity. In developing his case, he says:

> Today we have no skulls or fragments of *Sinanthropus* (except two teeth), no reconstruction. . . . All we have are *models* fashioned by Weidenreich. . . . How reliable are these models? . . . Are they accurate casts of the originals, or do they reflect what Weidenreich *thought* they should look like? . . . Why do his models differ so greatly from the earlier descriptions? [Gish, 1979:138]

Gish would have us believe that the entire surviving corpus of evidence for the existence and form of *Sinanthropus* is contained in the model or models constructed by Weidenreich, despite subsequent fossil finds. Having set up this strawman, he then denounces it without ever looking at the evidence upon which it is based. This he does with the words, "I consider these models of Weidenreich to be totally inadmissible as evidence related to the taxonomic affinities of *Sinanthropus*," concluding with, "If such a case were ever brought to court there would not be the slightest doubt that such hearsay evidence would be ruled inadmissible" (Gish, 1979:138).

The only thing he offers to support his contention that Weidenreich is not to

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be believed is his repeated allegation that the conclusions of Weidenreich, and others as well, are supposedly at such variance with earlier work. As he claims, "This model is so glaringly different from the earlier description of *Sinanthropus* . . . that I strongly suspect Weidenreich was guilty of the same lack of objectivity and preconceived ideas that motivated Black" (Gish, 1979:136).

This same charge of a supposed difference between earlier and later accounts of the form of *Sinanthropus* is also leveled at his principal source of information, the 1957 text by Boule and Vallois, *Fossil Men.* In Gish's words, "The account of Boule and Vallois in this section varies so decidely from earlier descriptions of *Sinanthropus*, published elsewhere by Boule, that it is probable that this section was written by Vallois after the death of Boule" (Gish, 1979:136). Presumably, Boule's original description was more to be trusted because, as Gish claimed, "Boule had visited Peking and Choukoutien and had examined the originals" (Gish, 1979:133). This, however, is pure invention. Boule did not visit Peking, he did not visit Choukoutien, and he never saw the original specimens. Instead, as he made quite clear in print, he relied entirely upon the photographs and information furnished to him initially by Black and later by Weidenreich.

I have already shown that the earliest account of *Sinanthropus* written by Marcellin Boule differs from that of Davidson Black not in its description of the evidence but only in the name by which it is called. The only other separate account written by Boule appeared seven years later. Gish quotes from this to justify his conclusion that the *Sinanthropus* specimens were "monkey-like" creatures who could not have been human ancestors because they were being hunted and eaten by "true Men" (Gish, 1979:134, 140).

That 1937 paper by Boule, however, was the first printing of what Gish refers to as the "extensive section" (1979:132) on *Sinanthropus* that later appears in the text of *Fossil Men*, and the same photograph of *Sinanthropus* given by Black to Boule appears in both (Boule, 1937:7, fig. 3; Boule and Vallois, 1957:134, fig. 86). This is the same section which Gish suggests was written by Vallois after Boule's death. On the very same page of that paper which Gish cites as the source for his view that the skulls were "monkey-like" (ignoring the fact that the words *monkey-like* never appear and that the rest of his quote is garbled from several other pages), Boule renders his summary judgment of the Choukoutien discoveries:

> il n'en est moins evident que, tant par le volume de leur cerveau que par ce que nous savons de la structure anatomique de leur tete osseuse, le Sinanthrope et son frere le Pithecanthrope s'intercalent, dans le serie des primates superieurs, entre les grands singes anthropomorphes et les hominiens. [Boule, 1937:21]

which translates to:

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> It is evident, by the volume of their brains and by what we know of the structure of their skulls, *Sinanthropus* and his brother *Pithecanthropus* fall between the great anthropoid apes and men properly so called in the series of higher primates." [Boule and Vallois, 1957:145]

This is not my own translation but is taken directly from that "extensive section" on *Sinanthropus* in the English edition of *Fossil Men*, which Gish suggests was written by Vallois after the death of Boule. It is faithful to the letter to Boule's rendition of twenty years earlier. In fact, if one goes through Boule's 1937 paper, section by section, paragraph by paragraph, and line by line, and compares it with the relevant segment in *Fossil Men*, it is evident that Vallois made only very minor editorial changes for the final version.

The supposed differences in the earlier and later accounts of the nature of the material discovered at Choukoutien are simply a fabrication by Gish designed to cast doubt on the work of some of the most respected students of the human fossil record. It is the creationist position, then, and not the work of Black or Weidenreich, which should be regarded as based, at best, on hearsay evidence when not grounded in demonstrable falsehood. The charge that the evidence for evolution would be ruled inadmissible in court is actually an example of Orwellian "newspeak." In the 1982 Arkansas court decision, it was the creationist viewpoint that was shown to be without merit.

Now let us turn to a consideration of the evidence itself. Despite Gish's claim that the only surviving evidence for the form of *Sinanthropus* is Weidenreich's model, we have the series of profusely illustrated monographs by both Black and Weidenreich to draw upon, to say nothing of the quantities of material discovered since World War II. Gish has even written that not just the fossils but the very *site* is a hoax: "There is serious doubt that a cave existed at either level" at Choukoutein (Gish, 1979). Figure 4 records my 1980 visit to excavations at these "nonexistent" caves.

Creationists have consistently misunderstood or misrepresented the nature of the fossil record of human evolution. They have tended to vacillate between denying the evidence and trying to force selective parts of it into easy categories of *ape* (or *monkey*) and *human* (meaning modern human), despite the fact that we humans have rather diligently and successfully sought out our fossil ancestry.

Let us refer to some of the specific evidence. Figures 5 through 7 show some of the massive amount of evidence unearthed at Choukoutein. Compare them with claims that no such evidence exists. If the early discoveries are forgeries, how could the *internal structure* of a fossil have been faked? Figure 5 is an X-ray view of one of the early crania showing intricate anatomical details. Figure 6 is an external view. The back part of a skull found in 1934 (L3) fits perfectly with a front portion found in 1966 (Figure 7).

Homo erectus remains are known from Africa, Asia, and Europe. Late

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examples grade into early Neandertal forms (some scholars even treat Neandertal as late *erectus*). In summary, *Homo erectus* is a well-documented, well-dated, and widespread hominid intermediary fossil antedating *Homo sapiens.*

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Creationists and Neandertal

Ernest Conrad

The nature of Neandertal "man," probably the most famous hominid fossil form, has long been a subject of debate. While Darwin, Wallace, and others were formulating a coherent theory of evolution, Neandertal skeletons were first discovered. While the human characteristics of Neandertal were clear, they exhibited primitive characteristics as well. As a result, they became a Victorian "missing link" to Darwinists but an example of syphlytic Roman legionnaires or funny-looking modern *Homo* to others. Neandertal was the first recognized hominid fossil which seemed to be more primitive than modern humans but less primitive than apes.

Today, many anthropologists consider Neandertal remains, dating between 30,000 and 140,000 years, a variety of our own genus and species—typically *Homo sapiens neandertalensis.* Some paleontologists, such as Steven Stanley and others, classify Neandertal as a late form of *Homo erectus*, distinct from *sapiens.* Others treat Neandertal *and* late *Homo erectus* as "Archaic *Homo sapiens*" rather than as a unique species or subspecies. (Taxonomists even debate the very existence of a subspecies category, so nomenclature is debatable in various ways.) All agree that Neandertal predate contemporary modern humans. They are paradoxically the best known yet one of the least-understood hominids.

Some paleoanthropologists distinguish between western Europe's "Classic Neandertals" (the first specimens discovered by Europeans and typically the most robust) and "Progressive Neandertals" found in Eurasia and perhaps in Africa (where so-called Rhodesian Man represents an early but advanced example). They typically lean toward the idea that "Classic" forms were an evolutionary dead end or variational extreme—perhaps a cousin of direct ancestors. Others view

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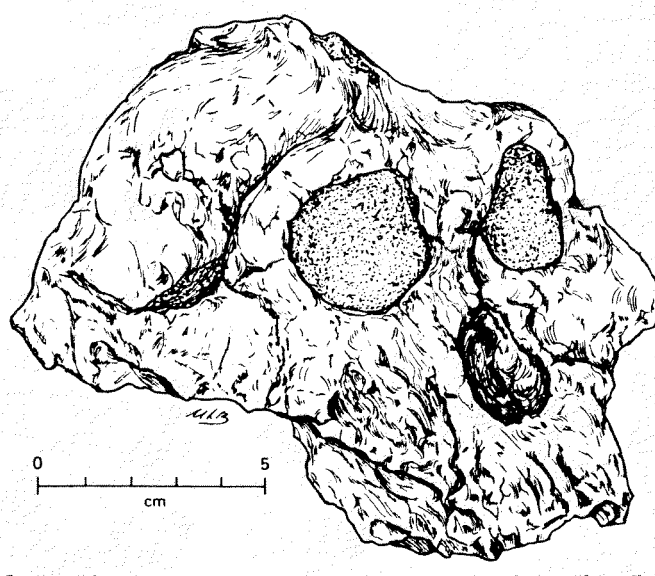

FIGURE 1: Australopithecus robustus, *a late robust australopithecine from Ileret, east of Lake Turkana, Northern Kenya (drawing by M. L. Brace, from C. L. Brace et al., 1979, p. 44).*

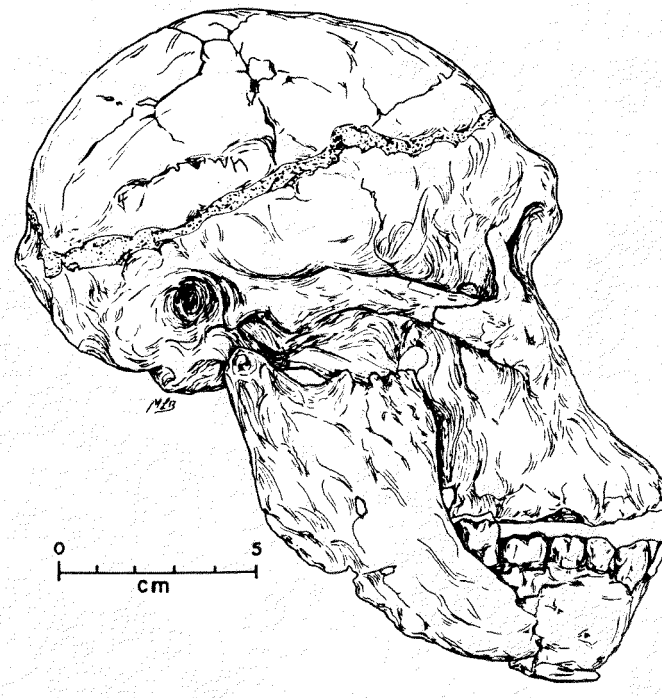

FIGURE 2: Australopithecus africanus, *a gracile australopithecine skull and jaw from Sterkfontein, Transvaal, South Africa (drawing by M. L. Brace, from C. L. Brace et al., 1979, p. 37). Skull and jaw are from different individuals.*

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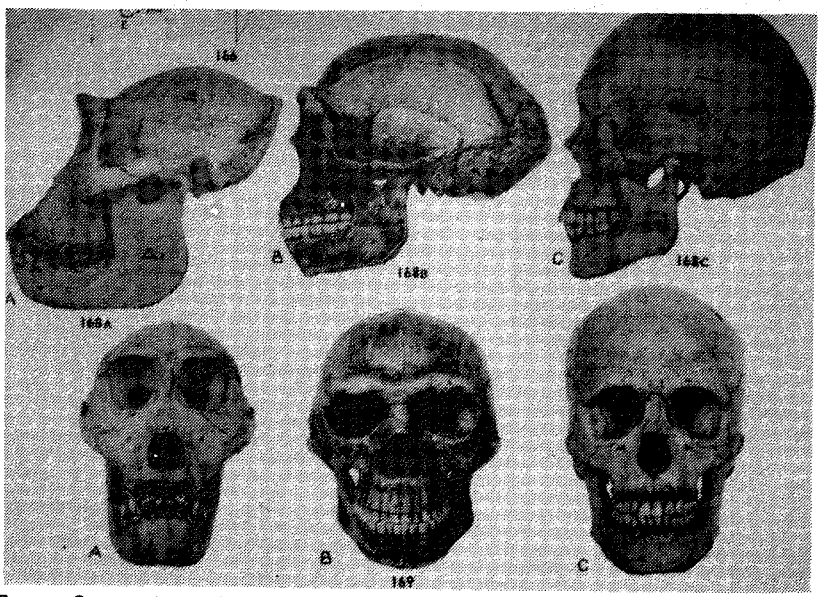

FIGURE 3: *Female gorilla,* Homo erectus, *and* Homo sapiens *skulls compared by Weidenreich, demonstrating that* erectus *is an intermediate form.*

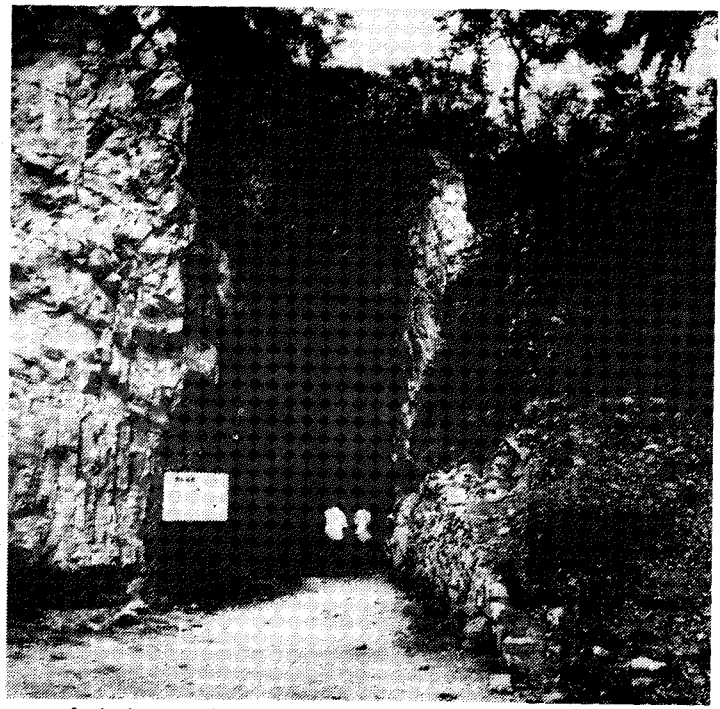

FIGURE 4: *A photograph taken by C. L. Brace at the Choukoutien Upper Cave.*

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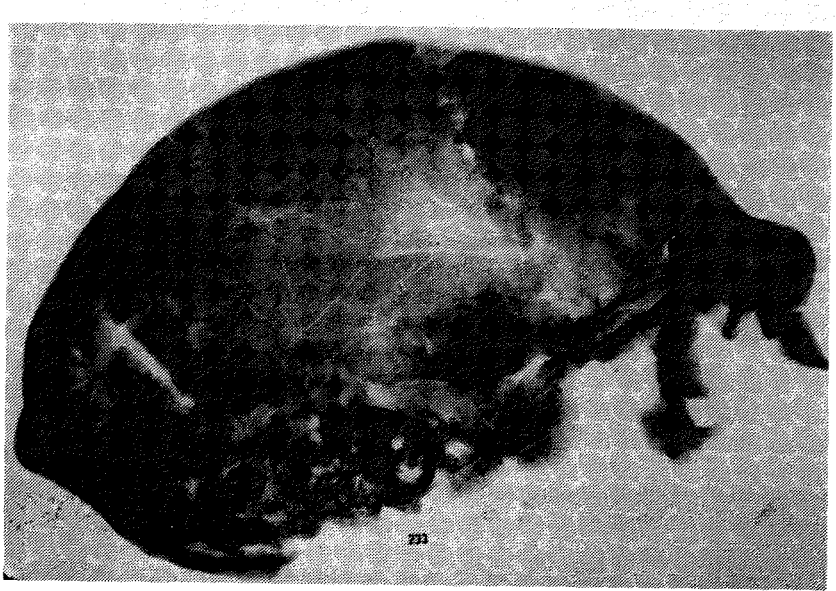

FIGURE 5: *An X-ray view of Sinanthropus II* (Homo erectus).

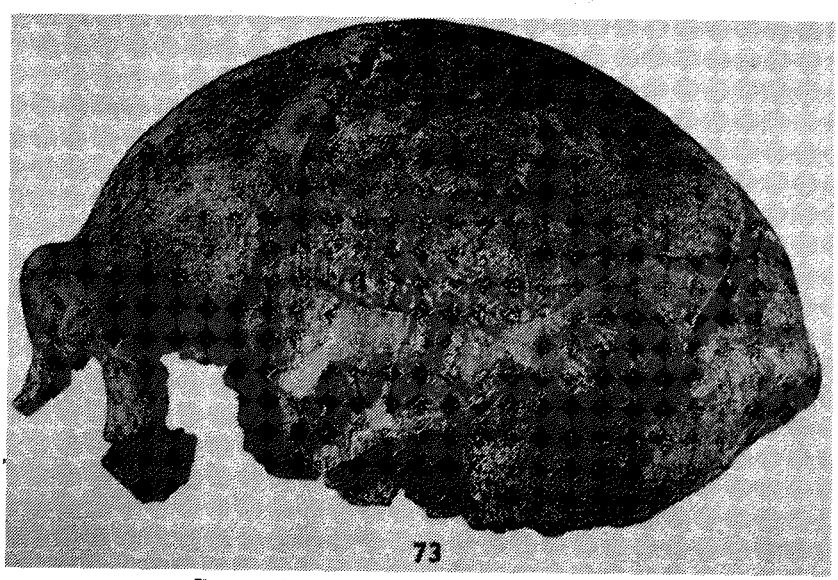

FIGURE 6: *An external view of Sinanthropus II.*

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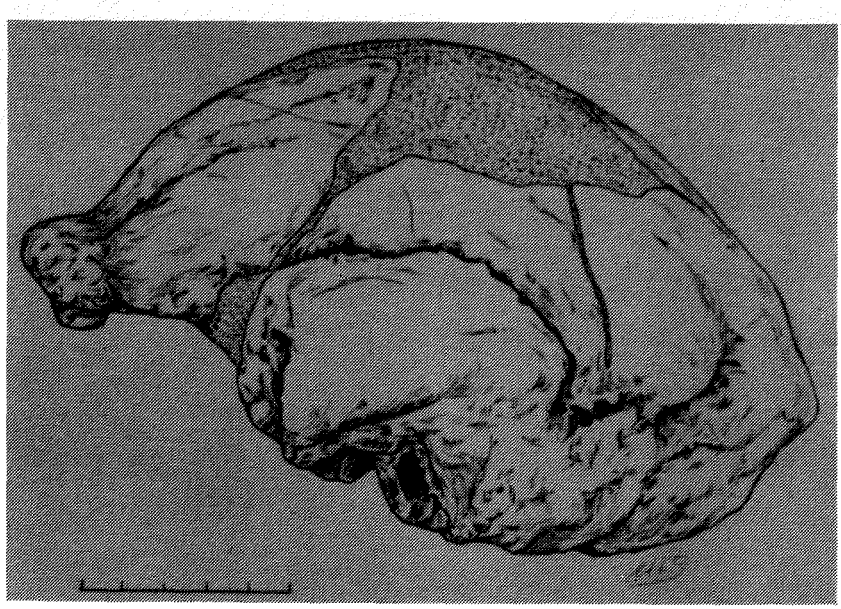

FIGURE 7: *Drawing by M. L. Brace of a cast of the L3 back end of a skull found in 1934 onto which the front section found in 1966 fits perfectly.*

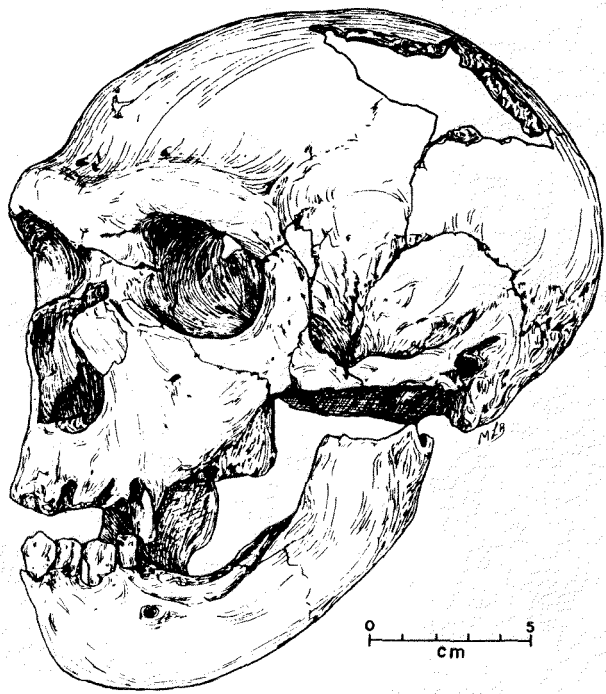

FIGURE 8: *A European Neandertal from La Chapelle aux Saints, southern France, approximately fifty thousand years old (drawing by M. L. Brace, from C. L. Brace et al., 1979, p. 117).*

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some of the "Progressives" as hybrids, directly ancestral to modern humans. Advocates of the view that Neandertal was a dead end (especially "Classic" forms) may suggest what is called the "Pre-Neandertal hypothesis," maintaining that there was a direct transition between *Homo erectus* and *Homo sapiens* (without a Neandertal species or subspecies).

Homo erectus, Homo habilis, and australopithecine remains clearly predate modern *Homo* stratigraphically, morphologically, and according to a range of radiometric dating techniques. The exact placement and role of Neandertal and the nature of the *Homo* transitional sequence remains debatable, but there is no question about the fact that Neandertals were people with cultural traditions and humanlike activities, such as ritualistic burial of their dead, group support of handicapped individuals, and the beginnings of artistic sensibilities. Indeed, one of the most fascinating Neandertal questions (totally ignored by creationists) is the nature of relationships between two possibly coexisting culture-bearing species, Neandertal and a separate archaic *Homo sapiens.*

Despite a few technical disagreements, including the very basic question about whether *Neandertal* is a defined taxon, a stage of human evolution, or a nineteenth-century terminological artifact, no one questions its hominid nature. As with any evolutionary topic which shows signs of lively debate concerning nuances, creationists have seized upon the nature of Neandertal.

The creationist view of Neandertal varies from arguments that Neandertal is an ape, a modern human with bone disease, or an extinct form of human or ape. Transitions are ruled out, of course. Anti-evolutionists find ways to read perplexity into complexity. A few quotations show some of the range of their claims:

> The Neanderthal race of cave-men (based on a skull cap attested by various experts to be that of an ape-man, a modern Cossack, a Negro, an early German and several other things, including that of an idiot) has a skeletal structure similar to that of modern day men and women who suffer from the endocrine disorder acromegaly . . . occurring in about one person in 10,000. [Pratney]

> As far as the stooped skeletal structure of Neanderthal is concerned, most anthropologists now believe this was due to disease, possibly arthritis or rickets. [Morris, 1974]

> It is my opinion from the research that the adult Neanderthal features that are so ape like are the result of a heavily functioning masticatory system and extremely old age, perhaps 150 to 200 years. [Cuozzo, 1980]

> In fact a number of the man fossils may represent peoples which had

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suffered degeneration as the result of sin. [Kofahl, 1977]

> Because of sin, mankind began to degenerate, and as groups left the central society for life in the wild, they degenerated even further. According to this evidence the Neanderthal and Cro-Magnon people lived near the Mid-East, while more degenerate types such as the Pithecanthropines and Australopithecines moved still further.
>
> [*Bible Science Newsletter*, 1980]

Let's look at these claims separately, starting with the degeneracy hypothesis. The idea that a sinful life-style caused Neandertal morphology and that the further people were removed from the central human population the more they degenerated is not a new position. A famous nineteenth-century anti-evolutionist, Hugh Miller, wrote in 1870: "The farther we move in any direction from the Adamic center, the more animalized sunk do we find the various tribes and races." Many Europeans of Miller's time had similar ideas about the supposed "primitive" nature of nonwhites. Such ideas lie at the historical roots of the current creationist degeneracy hypothesis.

Furthermore, from the standpoint of science, nothing is known about the power of "sin" as a force in nature that can turn an ordinary WASP into a Neandertal. Creationists will have to provide experimental evidence if they wish us to believe that the wages of sin are a backward trek through our evolutionary past.

About the creationist argument that the Neandertal fossils represent essentially modern humans in a diseased condition, much more needs to be said.

To begin with, it is important to realize that today paleoanthropologists reject the shambling, bent-kneed, slouching Neandertal as a myth stemming in part from Marcellin Boule's 1911–1913 "restoration" of an unfortunately chosen pathological skeleton which had arthritis in the neck, jaw, and spine. The *La Chapelle aux Saints* skeleton he studied was a pathological case not typical of the Wurm I Neandertal who was normally as upright as modern humans. When Boule published his findings, the majority of scientific opinion welcomed his filling of the gap in the procession of ape to human. But time did not freeze in 1911; very soon, his interpretations were challenged, tested, and changed. Some creationists, however, have fixed upon such early ideas, unfairly denigrating early paleoanthropologists and their descendents who have improved drastically upon early interpretations. A good discussion of Neandertal pathology has been summarized by Erik Trinkaus (1978) and Trinkaus and Howells (1979).

Since the diseased *La Chapelle aux Saints* skeleton was atypical, it should be obvious that an appeal to disease cannot be used to explain away all the clear differences between healthy Neandertals and modern humans. Some creationists, however, seem to reject the idea that *any* of the Neandertals were healthy, claiming instead that Neandertal features are simply the result of certain afflictions in

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ordinary humans. One of the clearest expositions of this view was made in 1978 by Rush K. Acton, an orthopedic surgeon. His *Impact Series* article for the Institute for Creation Research, entitled "Bone Disease Simulating Ancient Age in 'Pre-Human' Fossils," goes into some detail on disease and Neandertals and therefore warrants a response.

Overall, Acton's article is misleading. Since he had no apparent first-hand experience with the data, his medical credentials end up contributing little to his analyses of positional and locomotor behavior of fossil forms. Some of his comments are true, some false, and some vague. Together, they do not support his conclusion: "Most examples of the 'fossil men' can best be explained as variant forms of man or ape with an occasional example of outright fraud." Let us, however, look at his main points and respond with scientific counterpoints.

POINT: "A German anatomist, Rudolph Virchow, said in essence that the [1856 Neander Valley] fossil was the remains of modern man (*Homo sapiens*) afflicted with rickets and arthritis" (Acton, p. ii)

COUNTERPOINT: T. Dale Stewart, an eminent authority on Neandertal at the Smithsonian Institution, informed me that:

> Virtually all anthropologists agree that Virchow was mistaken in believing Neandertal to be an abnormal individual. In Virchow's day, it was not understood how old the Neandertal skeletons were, hence it was assumed that the bones being examined were modern man with some type of disease.

Paleopathology exists precisely to recognize evidence for disease in earlier human populations and to prevent pathological conditions being considered in the normal range for those populations. This is what was done with the *La Chapelle aux Saints* specimen, and Neandertal came to be more accurately depicted as a result. But this did not rule out Neandertal altogether. Paleopathology also helps to show what features are normal and *not* the product of disease. Virchow did not understand this and thereby went too far. He even attributed the massive supraorbital torus (brow ridge), which forms the double arch morphology of bone overhanging the eyes, to several stupendous blows to the head!

POINT: "When rickets occurs in children it produces a large head due to late closure of the epiphyses and fontanelles. The forehead is high and bulbous, the 'Olympian front' . . . These features approach those of the classic Neanderthal skull" (Acton, p. ii)

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COUNTERPOINT: Neandertal skulls are not high and bulbous but show a long, low cranial vault with only moderate bossing. Here, Acton's knowledge of bone diseases is not matched by a working knowledge of Neandertal fossils, and so his comparison falls apart.

POINT: "[Francis] Ivanhoe goes on to make a very good case for the correctness of Virchow's assumption that Neanderthal was merely modern man with rickets" (Acton, p. iii).

COUNTERPOINT: In 1970, Francis Ivanhoe wrote an article in *Nature* entitled "Was Virchow Right About Neanderthal?" Acton makes much use of it in his *Impact Series* piece. Creationists commonly assume that, if something supportive of their view is published in a major scientific journal such as *Nature*, the conclusions in the article must be valid. This, perhaps, was Acton's error here.

A basic problem with the rickets claim is that, if it is to account for Neandertal features, all Neandertal fossils would have to show signs of it. But Erick Trinkaus writes:

> The Neandertals were an extinct human group that immediately preceded anatomically modern humans. There was nothing in their total morphological pattern that would indicate a consistently abnormal or diseased condition. This conclusion has been substantiated by numerous subsequent discoveries of Neandertals in Europe, the Near East, and Central Asia. [1982a]

Ivanhoe and Acton, in specifically pointing to rickets, note that it results in a softening of the bones, leading to bowing of the long bones and hence the stooped posture associated with "Classic Neandertals." But Trinkaus points out:

> Many adult Neandertal have prominently bowed radii and femora and this bowing appears to be present in some immature Neandertal. However, it is always an accentuation of the normal curvature of the radial of the femoral diaphysis, and it never assumes the irregular curvature associated with rickets. None of their humeri, ulnae, tibiae, or fibulae are unusually curved. . . .
>
> This discussion should make it apparent that Ivanhoe's statement that "most features of the characteristic Neanderthal morphology are the result of a form of rickets" is without empirical basis. [1982b]

Since Ivanhoe wrote in *Nature* and creationists consider this a very prestigious publication, they automatically consider his findings accurate. However,

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here's what A. Bilsborough wrote in *Nature* two years after Ivanhoe's article appeared:

> Certainly there is no reason to consider that any of the facial characteristics of the European Neanderthals result from pathological changes. . . . The available data indicate there is no reason to consider that the European Neanderthal crania are pathologically deformed. [1972]

Do I make an appeal to authority here? Yes, I do. My purpose is to show that creationists frequently *misuse* authority. They cite prestigious sources without checking to make sure that the views expressed are still current and were not effectively refuted later. They operate under the assumption that any published interpretation is as good as any other. Although this contradicts common sense, it does fit well with their demands for "equal time."

Acton is no exception. As a result, his readers never learn that Ivanhoe's interpretation of the data, seemingly influenced by Virchow, has been disputed by several leading paleopathologists and that their critical comments and reviews of the data were available and published before Acton wrote in 1978. Paleopathology is not a guessing game in which it is acceptable to side with discredited authors "crying in the wilderness." Science is not prophecy; it is a consensus of opinion based upon a rational study of the evidence by the participants.

POINT: "It is possible that some of the changes that occur in fossil bones are attributable to a condition called Paget's Disease or Osteitis Deformans. This occurs most often between fifty and seventy years of age . . ." (Acton, p. iii).

COUNTERPOINT: If this condition develops between fifty and seventy years of age, it would be difficult to relate it to the Neandertal populations. Few Neandertals made it to fifty. Practically none ever reached seventy years of age, and the average life span was thirty to thirty-five years.

Again, Acton's knowledge of his own specialty does not carry over to paleoanthropology where the life span of the Neandertals is widely known. We must remember that, because of their early discovery in Forbes' Quarry at Gilbralter in 1848, the abundance of their fossil remains (three-hundred-plus specimens—Acton misleadingly states "over one hundred"), and their convenient location in western Europe, Neandertals have been the most intensively studied of the fossil hominids.

A demographic study of thirty-nine burials gives credence to the point that Neandertals did not survive long enough to have Paget's disease. Kennedy states:

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> . . . 40% are infants and there is a mortality of slightly over 10% for juveniles. Adults who died between their 21st and 30th years make up about 15% of the sample, while those who died between 31 and 40 years of age constitute 25%. Less than 3% of the population lived beyond an age of forty years. And persons in their sixth decade are rare indeed. [1975]

Furthermore, Paget's disease is very well known and, to date, not one example of it has been found in the Neandertal remains. Clearly, this disease cannot be a factor in Neandertal morphology, even though Acton goes to great pains to argue that the disease produces an apelike appearance in its victims.

POINT: "A specialist in venereal diseases in London named D. J. M. Wright examined the collection of Neanderthal bones in the British Museum of Natural History and reported that these bones could be merely modern man affected by congenital syphilis" (Acton, p. iv).

COUNTERPOINT: Again, knowledge of disease does not make one an expert on the Neandertals. So I submitted this argument to British anatomist A. J. E. Cave. Professor Cave held the chair of anatomy at St. Bartholomew's Hospital in London and is considered an expert on the interpretation and pathological meaning of Neandertal fossils. Professor Cave replied:

> No competent morphologist could confuse the frontal bossing of the congenitally syphilitic cranium with the distinctive configuration of the Neandertal skull. Neandertal was a morphologically distinct type of rational human being, which appeared and disappeared when and why, we know not.

Of course, creationists will reject the testimony of Cave and prefer that of Wright. But, in order to do so, they will have to take the position that *all* the Neandertals had syphilis, since this is how they wish to account for Neandertal features in general. That this won't work is suggested by this conclusion of Kennedy: "The health status of Neanderthal man was probably neither better nor worse than that of other hunting-gathering peoples prehistoric and contemporary." And there is nothing to support the idea that all hunter-gatherers have syphilis.

This confirms a statement by Trinkaus, cited earlier, in reference to rickets. In fact, all the specific creationist disease claims suffer from the same problem. The evidence does not show that all Neandertals were alike in the diseases they had.

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Acton overlooked another problem as well: if any given disease, or a combination, explains Neandertal morphology, then why do anatomically modern people living all over the world in many varied climates, cultures, and conditions not look like Neandertals when they suffer from the very same diseases? How is it that our hospitals do not regularly report this phenomenon?

Acton's case collapses in the face of both evidence and logic.

Now that the disease hypothesis has been ruled out, it is important to discuss the differences between healthy Neandertals and healthy modern humans. The overall morphology of the Neandertals is very distinctive. In 1927, G. M. Morant conducted a systematic statistical study of the multiple cranial characteristics of Neandertal. The study has become a landmark and points out the major distinctions between *Homo sapiens* and *Homo sapiens neandertalensis.* As reported by Campbell:

> (1) The skulls are particularly characterized by the absolutely and relatively large size of the facial skeleton. (2) Nearly all measurements designed to assess the sagittal flattening of the cranial vault relegate the Mousterian skulls to positions entirely outside the interracial distributions for modern man. (3) The axis of the foramen magnum is more deflected from the verticle than in modern races. (4) The skulls are distinguished from all modern types by having a greater traverse flattening of the vault. (5) There are more vertical walls and height that is peculiarly small in proportion to the breadth. (6) As regards the breadth-length indices of the separate frontal, parietal, and occipital bones, some fall entirely outside the interracial range for modern skulls. [1979]

Although Morant's work was published over fifty years ago, creationists are still fond of remarking that, if we gave a Neandertal man a shave, a haircut, and a bath, if we dressed him in a business suit and put him on the subway, no one would give him a second look. This is a curious claim for creationists to make in the light of their other claim that Neandertals represent humans so diseased that their stature and facial features have been altered to a most pronounced degree. Creationists will have to choose which side of the fence they wish to be on.

That they can take both sides at once shows how fundamental is their desire to belittle any real difference between Neandertal and modern humans. Creationism cannot brook transitional forms and so must explain them away—even at the cost of contradiction.

The idea that Neandertal was just like you and me is not new nor unique to creationists, however. As Millar writes:

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> Indeed, W. L. Duckworth [British professor at the turn of the century] once exuberantly exclaimed that if Neandertal man entered a bar in modern dress the majority would not notice him. One marvels at the sort of person Duckworth drank with.

As it turns out, this imagery actually helps demonstrate human evolution. It is true that if a Neandertal were put in modern clothes he would not be mistaken for a gorilla. But people would notice the difference. After all, when someone today has an even slightly robust face and only mildly protruding eyebrow ridges, people are likely to comment on how "Neandertal" he looks. A real Neandertal would be even more obvious.

Continuing the imagery, if we gave *Homo erectus* a shave and a haircut, dressed him up, and put him on the subway, people would not only notice, they would move to the other end of the car. And if you gave *Australopithecus afarensis* (Lucy) a shave and a haircut, dressed her in modern clothes, and put her on the subway, everybody would get out and call the zoo! This should give you an idea of what a transitional series we have in the human fossil record.

The overdrawn separation between humans and apes is a creationist construct based upon the simple fact that we are alone in our species (*sapiens*), alone in our genus (*Homo*), and even alone in our family (Hominidae). All of our relatives are dead. There are no living Neandertals to share our species, no pithecanthropines to share our genus, and no australopithecines to share our family. There's just us. And until the eighteenth century, Europeans knew nothing of African apes. Prior to then, they thought they were alone in their superfamily as well (the Hominoids). At the time our religions were established, there were no life forms to tempt us away from our anthropocentrism. This is why it is so easy for us today to believe that we are somehow separate from the animal kingdom and may have been specially created. Paleoanthropology is, for many, a painful revelation.

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A Brief Bibliography on Human Evolution

compiled by John R. Cole

The bibliographies of the articles presented in this issue provide a good source of more detailed reading matter. In addition, I would suggest a few additional sources which are widely available:

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Plagiarized Errors and Molecular Genetics: Another Argument in the Evolution-Creation Controversy

Edward E. Max

Most scientists regard the evidence for evolution as overwhelming. Thus, in their conviction that evolution has already been thoroughly and sufficiently documented, they sometimes fail to consider how new discoveries can be applied to support evolution. In this article, I draw together some discoveries of the past few years from my own field of molecular genetics. When these findings were initially reported, their implications for the creation-evolution controversy were not explicitly discussed; but they offer an interesting new twist to an old argument and provide evidence for evolution that is conceptually simple enough for the interested layperson to appreciate.

The new molecular evidence bears on a question which, in my opinion, represents one of the few cases in which a creationist argument had demonstrated logical consistency and had fought the evolutionary position to a deadlock. This is the question of how to interpret the *similarities between modern species*, especially the similarities observed at the molecular level. As we will see, the recent discoveries from molecular genetics resolve this deadlock in favor of evolution.

The Evolutionary View of Species Similarities

Consider first the interpretation of species similarities from the evolutionary viewpoint. Although present-day humans and gorillas may appear quite different from each other at first glance, their internal organs and physiological function

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are extremely similar. Just as the resemblance of two siblings suggests a common parentage, resemblance between species suggests common ancestors. Evolutionists believe that humans, gorillas, and chimpanzees evolved from a common ancestor—an apelike creature that lived perhaps five to ten million years ago, rather recently on the geological time scale. (The thought that humans and apes might share a common ancestor seems particularly unacceptable to creationists because of theological implications and the clear contradiction to the biblical account of human creation.) Species less similar to humans than are apes—mice, for example—are believed to have branched off millions of years earlier from a common primitive mammalian ancestor. Evolutionary family tree diagrams that express such relationships between species have been constructed by evolutionary biologists by analyzing similarities of present-day organisms. In many cases, fossilized remains of extinct species can be used to support the features of such evolutionary trees; fossil evidence will not, however, be discussed in this article.

Another extensive source of data that has been of major importance in constructing tree diagrams is the species comparison of *proteins*. Proteins are large biological molecules made of subunits called amino acids that are attached to one another in chains, like the cars of a train. There are twenty different kinds of amino acids used in proteins, and most proteins contain hundreds of these subunits. Each protein has a specific number and sequence of amino acids, and this sequence determines what properties that protein will have. The sequence information specifying the structure of each protein is stored in "blueprint" form in the organism's genes. Biochemists can purify proteins and learn the exact sequence of their amino acids. Considerable effort has gone into comparing the sequence of similar proteins isolated from different species. For example, one protein called "cytochrome *c*" has been examined in more than eighty species. These cytochrome *c* amino acid sequences represent "digital" bits of data that can be used to quantify differences between species, and these differences can be used to construct evolutionary trees much like those based upon comparisons of "analog" features of body structure. Such protein sequence trees—as well as trees based upon gene structure similarities—agree remarkably well with the evolutionary trees derived earlier from anatomic similarities. The agreement of evolutionary trees constructed from such completely different sorts of data has been taken by evolutionists as evidence of the validity of the intellectual framework on which the trees are based: the theory of evolution (*see*, Jukes 1983, 1986).

The Creationist View on Species Similarities Leads to a Deadlock

However, creationists have an alternative interpretation of the amino acid se-

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quence similarities reflected in the evolutionists' trees. They say that such sequence similarities in "related" species simply reflect the creator's choice to design similar species to function similarly, not only at the level of bones, muscles, and organs but also at the level of protein function—hence the amino acid sequence similarities.

Thus, the similarities between species in anatomy and protein structure can be interpreted in two entirely different ways. The evolutionists say that the similarity between features of, for example, humans and apes reflects the fact that these features were "copied" from a common ancestor; the creationists say that the two species were created independently but were designed with similar features so that they would function similarly. Both views seem consistent with the similarity data, but which view is correct?

A Possible Way to Resolve the Deadlock

One way to distinguish between copying and independent creation is suggested by analogy to the following true cases from the legal literature. In 1941, the author of a chemistry textbook was the plaintiff in a suit charging that portions of his textbook had been plagiarized by the author of a competing textbook. In 1946, the publisher of a trade directory for the construction industry made similar charges against a competing directory publisher. In both cases, mere *similarity* between the contents of the alleged copies and the originals was not considered compelling evidence of copying. After all, both chemistry textbooks were describing the same body of chemical knowledge and both directories listed members of the same industry, so substantial similarity would be expected even if no copying had occurred. However, in both cases *errors* present in the "originals" appeared in the alleged copies. The courts judged that it was inconceivable that the same errors could have been made independently by each plaintiff and defendant and ruled in both cases that copying had occurred. The principle that duplicated errors imply copying is well established in copyright law. (In recognition of this fact, directory publishers now routinely include false entries in their directories to trap potential plagiarizers.)

Can "errors" in modern species be used as evidence of "copying" from ancient ancestors? In fact, the answer to this question appears to be "yes," since recent molecular genetics investigations have uncovered some examples of the same "errors" present in the genetic material of humans and apes. To understand these findings it is necessary to know a little about deoxyribonucleic acid (DNA), the chemical molecule in which genetic information is stored.

In one respect, the basic structure of DNA resembles that of proteins: both are made of linear chains of subunits. (Apart from this common feature, DNA

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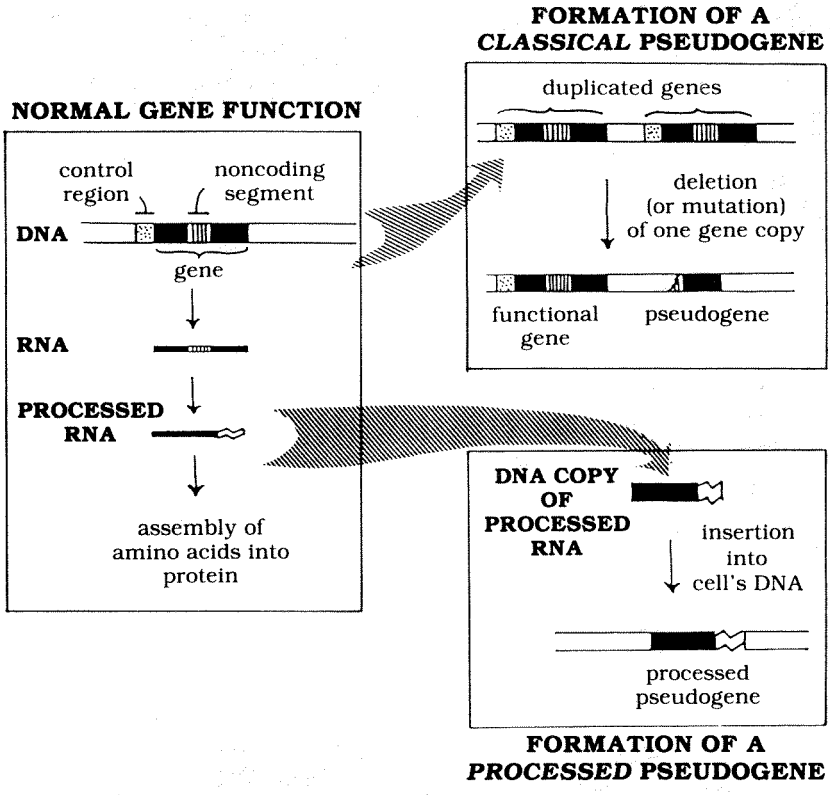

Figure 1: *How genes function normally and how they give rise to pseudogenes.*

and protein have many differences, which need not concern us here.) The subunits in DNA are called *nucleotides*, and the sequence of these nucleotides contains the genetic information. This information includes not only the "blueprint" specifying the sequence of amino acids in proteins but also various sorts of "punctuation"—control signals that ensure that the proteins are made in the proper amounts in the proper cells. The DNA acts somewhat indirectly in specifying protein structure. As diagrammed in the left panel of Figure 1 (above), this information is first copied into a molecule called ribonucleic acid (RNA). This initial copy of RNA undergoes several structural alterations, known collectively as *processing*. These alterations include the removal of unnecessary noncoding sequences from the RNA (the cross-hatched region in the figure) and some additions (represented by the wavy "tail" in the figure) that promote proper functioning of the RNA in the cell. It is the "processed" RNA that participates directly in the assembly of amino acids into proteins. The expression of a gene as an RNA copy is very tightly controlled, generally by highly specific regulatory sequences

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(represented in the figure by the stippled region) that occur in the DNA near the position where the RNA copy should begin but *outside* the copied region.

Recombinant DNA technology has in recent years allowed scientists to determine the sequence of nucleotides in segments of DNA from many species, and several million nucleotides' worth of information has accumulated. These sequences have vastly increased our understanding of how genes normally function; but, more to the point of this article, they have provided a treasure trove of genetic "errors" that are potential clues to the analysis of copying discussed earlier. In considering these "errors," I will focus upon two types of *pseudogenes*—that is, DNA sequences which are clearly related to known functional genes but which are apparently nonfunctional because of specific sequence alterations.

Pseudogenes: Genetic Errors of Two Kinds

The first type of pseudogene to be discovered (which I call the *classical* pseudogene) apparently arises from mishaps in a pattern of gene alteration that has been important to the development of normal functional genes: the pattern of duplication and differentiation. This pattern is evident from the frequent observation (in DNA from a variety of species) of blocks of sequences that have apparently been duplicated so that two or more repeats of similar sequences appear side by side. Presumably at the time of duplication each copy had an identical sequence. As DNA sequences are copied from generation to generation, *mutations* (mistakes in the normally accurate copying of DNA) can accumulate independently in the duplicated sequence copies. Some mutations may have no effect on the function of the gene. Others may lead to a protein that has a different function from that of the original gene. (Such differentiation of duplicated genes to develop new functions apparently accounts for a significant part of the expansion in complexity of the genes of higher organisms.) Finally, still other mutations, especially large deletions in the gene or alterations in the "punctuation" signals mentioned earlier, may completely destroy the function of a gene sequence and render it a pseudogene (*see*, Figure 1, upper right panel).

The crucial defects in a pseudogene can often be recognized by comparing its sequence with that of the related functional gene. The kinds of mutations that destroy gene function are well known from studies of mutations that have disabled crucial *non*duplicated genes, thereby causing genetic diseases. Such defective nonduplicated genes tend to disappear from populations over time because individuals lacking a functional copy of the gene are less capable of surviving to produce offspring. However, when a defective gene exists alongside a normal functioning copy, the abnormal sequence is usually harmless and may be perpetuated in the population as a pseudogene. *Numerous* pseudogenes of this type have

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been found in DNA from a variety of organisms, including humans.

An entirely different class of pseudogenes, known as *processed pseudogenes*, arises from naturally occurring insertions of extra gene copies into the cell's DNA. These inserted copies apparently derive from RNA molecules since they bear various features characteristic of the normal "processing" of RNA molecules—hence, the name *processed* pseudogenes. (*See*, Figure 1, lower right panel. Note that the processed pseudogene lacks the noncoding region [cross-hatched segment] present in the original DNA and includes the "tail" sequence [wavy line] that was added to the RNA during processing. Both of these features indicate the derivation of the pseudogene from processed RNA.) Unlike classical pseudogenes, which are usually found close to the functional genes from which they are derived by duplication, processed pseudogenes are apparently inserted into DNA at random locations. This randomness is what one would expect for a sequence derived from an RNA molecule that can float freely away from its source gene (from which it was orginally transcribed) before a copy is reinserted back into the DNA. Even if it encodes a correct amino acid sequence, a processed pseudogene is usually nonfunctional because it lacks the control sequences necessary for gene expression.

How Ancient Errors Can Persist in Modern Species

Each pseudogene that we observe is the result of a genetic accident that occurred in a single individual living at a particular time. A pseudogene arising in a muscle or liver cell of an individual would never leave those organs and would "die" when the individual died. In order for a pseudogene to be represented in later generations, one must assume that it arose either in one of the sex cells of the individual (egg or sperm) or early enough in embryonic development that it was present in the sex cells as they developed.

How could such a nonfunctional sequence, arising in a single individual, come to be preserved in all individuals of the species? A likely mechanism is that the pseudogene happened to lie close to an advantageous gene that became prevalent in a population by natural selection (the pseudogene "rode on the coat-tails" of the nearby advantageous gene). This mechanism for the establishment of a gene variant is most effective in very small populations in which a single dominant couple may supply most of the genes for the next generation. It is likely that pseudogenes arise with high frequency but we observe only those few that are preserved by unusual circumstances.

The extra burden of carrying along even a large pseudogene sequence—for example, 100,000 nucleotides—is insignificant for a mammalian cell with approx-

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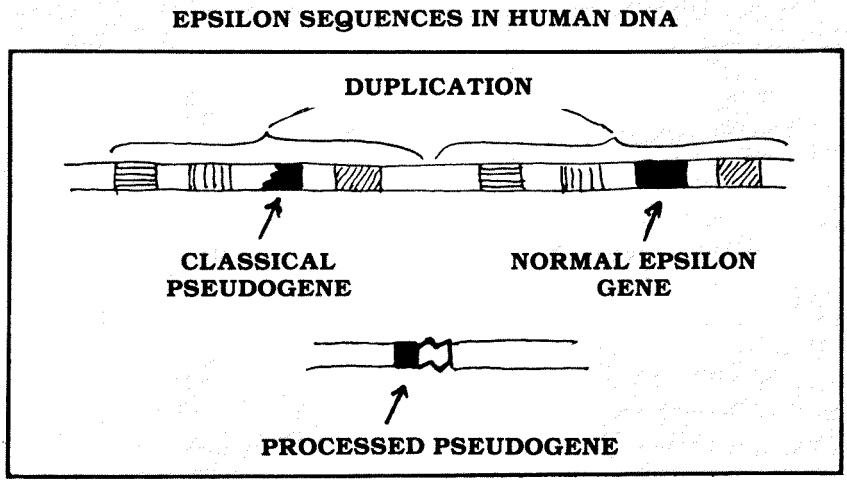

Figure 2: *The human gene encoding the kind of antibody protein known as* epsilon *(black rectangle) gave rise to two pseudogenes—one classical and one processed. Both of these useless sequences are present in essentially every cell of your body.*

imately three billion nucleotides' worth of information. There is, in any case, no known "proofreading" mechanism by which the cell might recognize and eliminate nonfunctional DNA. Functionless DNA sequences that experimenters have recently been able to insert into an organism's DNA are faithfully passed to descendants, and pseudogenes apparently behave similarly. The accumulation of functionless DNA is not completely uncompensated; deletions of DNA do occur, apparently as rare accidents that do not discriminate between functional and nonfunctional DNA. Deletions that remove crucial functional genes have been recognized as the cause of several genetic diseases, but other deletions that are harmless could remove some nonfunctional DNA. However, this is clearly an inefficient "garbage removal" mechanism, and, as an inevitable consequence of this inefficiency, substantial amounts of functionless "garbage" sequences have accumulated between the functional genes of most species. This is a surprising characteristic of the genetic material that was not appreciated until the past few years when recombinant DNA technology enabled molecular biologists to look beyond amino acid sequences to the structure of DNA itself.

The Argument from DNA to Evolution: Shared Pseudogenes

The crucial observation relating the discovery of pseudogenes to the theory of

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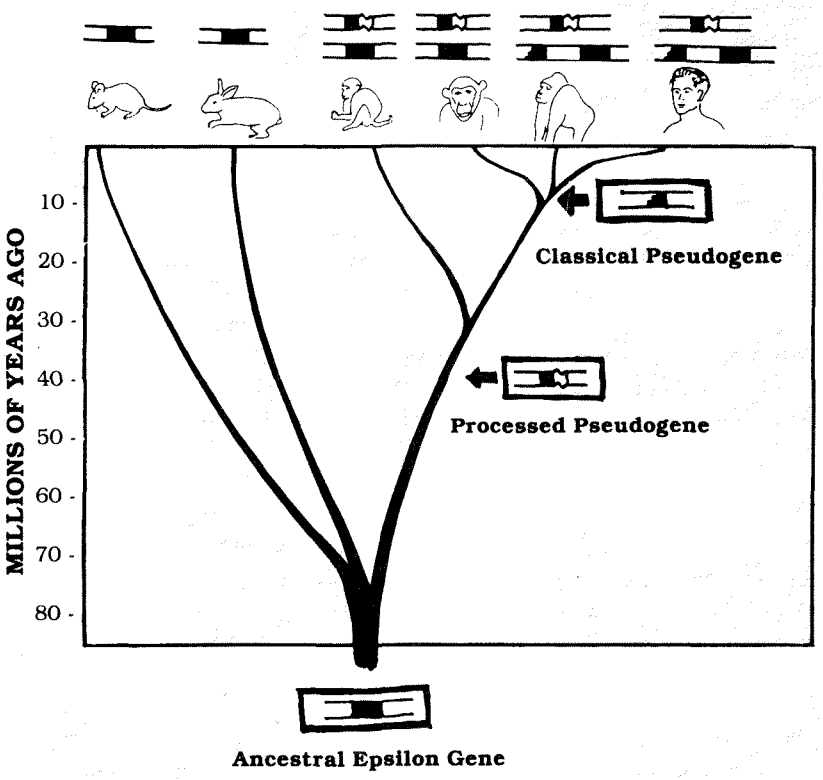

Figure 3: *Our epsilon pseudogenes are shared by other species. The figure illustrates a few of the branches on our "family tree" for which the question of epsilon genes has been investigated. Each species is drawn below a diagrammatic representation of its epsilon-related sequences. According to the evolutionary point of view, branching points that are lower on this tree represent more ancient species divergence. In this diagram, humans are represented as being related more closely to gorillas than to chimpanzees; this view is controversial but consistent with the epsilon pseudogene data.*

evolution is this: some pseudogenes are *shared between different species.* As examples, let's focus upon two human pseudogenes which I studied with colleagues in Dr. Philip Leder's laboratory at the National Institutes of Health (Max et al., 1982; Battey et al., 1982). Similar results were obtained by Dr. Tasuku Honjo and colleagues in Japan, who extended their observations to a variety of primate species (Ueda et al., 1982; Hisajima et al., 1983; Ueda et al., 1985). My colleagues and I were studying the human gene encoding immunoglobulin epsilon (a kind of antibody protein that participates in allergic reactions). We found that, in addition to the expected functional gene, human DNA contains two epsilon pseudogenes—one processed and one classical (*see*, Figure 2). Evidence from our

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laboratory suggested that the processed epsilon pseudogene was inserted at the same spot in both human and chimpanzee DNA. Dr. Honjo's group investigated the DNA of other species and found evidence for this processed pseudogene in gorillas as well as several monkey species (*see*, Figure 3). The classical pseudogene is found within a large block of duplicated genes (Flanagan and Rabbitts, 1982); the other genes in this block (hatched rectangles in Figure 2) are known to be functional, but one of the epsilon gene duplicates (black segments in Figure 2) suffered a deletion that removed DNA encoding about half of the amino acids of the epsilon protein, thereby completely disabling the gene. This pseudogene is apparently shared by man and gorilla but is not found in other apes or monkeys (*see*, Figure 3). Other examples of shared pseudogenes are known (*see*, for example, Chang and Slightom, 1984; Harris et al., 1984), and additional examples will almost certainly come to light as human and other mammalian DNAs are studied. But even a single example is sufficient to make a strong argument against the creationist viewpoint.

This argument can be understood by analogy with the legal cases discussed earlier in which shared errors were recognized as proof of copying. The appearance of the same "error"—that is, the same useless pseudogene in the same position in human and ape DNA—cannot logically be explained by independent origins of these two sequences. The creationist argument discussed earlier—that similarities in DNA sequence simply reflect the creator's plans for similar protein function in similar species—does not apply to pseudogenes because these sequences do not encode any functional protein. The possibility of identical rare genetic accidents creating the same two pseudogenes in ape and human DNA by *chance* is so unlikely that it can be dismissed. As in the copyright cases discussed earlier, these shared "errors" indicate that copying of some sort must have occurred. Since there is no mechanism by which sequences from modern apes could be copied into human DNA, or vice versa, the existence of the two shared pseudogenes leads to the logical conclusion that both the human and ape sequences were copied from ancestral pseudogenes that must have arisen in a *common ancestor of humans and apes.*

Extensions of the Shared Pseudogene Argument

This evidence for a common ancestor clinches the argument for evolution that follows from the shared epsilon pseudogenes. These pseudogenes link only humans and apes on the evolutionary family tree, but it is obvious that other shared pseudogene data can potentially be used to support other branches of the tree. By similar logic, other functionless features of DNA which are shared by two species and which are too complex or too specific to have occurred independ-

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ently by chance may be taken as evidence of common ancestry. Examples of such features already known to be shared between humans and chimpanzees include several other types of pseudogenes and the occurrence of other inserted sequence elements at the same location in the DNA of both species.

Another entire article could be written on these "other inserted sequence elements." Such elements occur with impressive variety in many species (*see*, for example, Kuff et al., 1983; Rogers, 1985; Weiner et al., 1986) and include sequences resembling retroviruses, which are known to insert their DNA into the DNA of cells that they infect. Two well-known examples of retroviruses are the pathogenic viruses causing AIDS and feline leukemia, but our DNA contains "endogenous" retroviral sequences that are apparently harmless. One such endogenous retroviral sequence, apparently "caught" by an ancestor of ours millions of years ago, is now found embedded at the same position in human and chimpanzee DNA (Bonner et al., 1982).

Evolutionists as early as Darwin pointed to vestigial structures—such as the functionless eyes of blind cave-dwelling animals or the rudimentary pelvic bones of some snakes—as supporting the evolutionary viewpoint. These structures serve no apparent purpose that could explain their design by a creator but can easily be understood in the evolutionary perspective as deriving from functional structures in ancestral species. Vestigial genetic sequences—that is, pseudogenes—provide exquisite examples of vestigial structures and, thus, especially compelling evidence for evolution. In contrast to some proposed vestigial organs, they can be studied in a variety of species, their relationship to their functional counterpart is obvious, and, especially for the processed pseudogenes, they can be assumed to be totally functionless from the instant of their creation (some organs cited as vestigial, for example, the human appendix, have been argued to have some function).

Absolute Proof? Science Can Advance Without It.

Do the shared pseudogenes *prove* that humans and apes had a common ancestor? Actually, *no* scientific knowledge is based upon unassailable proof of the sort that supports mathematical theorems. Instead, science advances by the accumulation of clues sought by persistent detectives (scientists) who try to derive logical and unbiased deductions from these clues. Like a jury presented with these clues, we can try to arrive at the most likely verdict even though we recognize that our facts are incomplete; there are no living "witnesses" to the eons of evolution, so we must do the best we can from the clues at hand. In the "case of shared pseudogenes," an unbiased jury would surely conclude that copying from a shared ancestor was the most likely explanation, consistent with the evolutionary inter-

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pretation. This conclusion would follow the logic of the actual legal principal of copyright litigation regarding shared errors as evidence of plagiarism, as discussed earlier.

One feature of science that distinguishes it from revealed religious belief (and evolutionists from creationists) is the scientific conviction that new knowledge about the past can be obtained from thoughtfully designed analysis of the real world. Creationists often claim that, since the origin of species occurred in the distant past, there is no scientifically valid way to study the process today and so evolution is not real science testable by experiment. However, even without actual experiments, a scientific hypothesis can be tested if it suggests a nontrivial prediction that can be verified, or falsified, by the collection of more data. Indeed, the interpretation of shared pseudogenes outlined here represents a hypothesis that can be tested because it suggests a rather startling implication: from a comparison between two nucleotide sequences *from a single species*—that is, the sequences of a processed pseudogene and of the functional gene from which it derived—it should be possible to predict accurately *which other species* will share the same pseudogene and which will not. To understand the logic of such a prediction, consider the fact that a newly formed processed pseudogene exists only in the species in which it arose, while an "old" processed pseudogene that arose in an ancient species should be found in modern descendants of that species. Thus, according to the evolutionary model, if we knew *when* a processed pseudogene arose and could thus fix its origin to a particular position on the accepted evolutionary "tree," we would predict that the same processed pseudogene should be found in modern species that derive from that point on the tree and not in any other branches. In fact, there is a way to estimate when a given processed pseudogene was formed. It turns out that "silent" mutations—that is, mutations that have no effect on the survival of the organism (like mutations in useless pseudogenes)—accumulate at a fairly uniform rate. This rate has been estimated by examining the number of "silent" sequence differences between corresponding functional genes in two species and by comparing this number with the approximate date of divergence of the same two species as indicated by the fossil record. Given this mutation rate and the number of sequence differences between a processed pseudogene and its functional source gene *from the same species*, one can estimate the date of origin of the pseudogene; then, using this date, one can derive predictions about appearance of the pseudogene in other species on the evolutionary family tree.

Consider, for example, the processed human epsilon pseudogene discussed earlier. The number of differences between this pseudogene and the corresponding sequence of the human functional epsilon gene suggests that this pseudogene arose about 40 million years ago. Therefore, the interpretation of processed pseudogenes described above would predict that mice and rabbits (which are thought to have diverged from the human lineage 70 to 80 million years ago,

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before the apparent origin of the pseudogene) should *not* carry the pseudogene, while apes and Old World monkeys (whose estimated dates of divergence from the human lineage [5 to 10 million and 30 million years ago, respectively] are both *after* the apparent pseudogene origin) *should* carry the pseudogene in their DNA. Available evidence confirms all of these predictions (*see*, Figure 3) and is also consistent with the evolutionary interpretation for the case of several other known processed pseudogenes (*see*, for example, Anagnou et al., 1984). More shared processed pseudogenes will certainly be discovered, and only time will tell how consistently such predictions are confirmed. Repeated instances of this kind of prediction and confirmation can supply convincing evidence for evolution even though some kinds of direct experiments to test evolution, such as experiments involving living dinosaurs, are impossible.

Conclusion

As new examples of shared pseudogenes are discovered by molecular geneticists, this information will surely join the immense body of clues from other disciplines which, collectively, already provide overwhelming evidence for evolution. Despite this impressive evidence, no scientist believes that all the answers are in on evolution or that our current understanding of pseudogenes is immune from revision in light of future knowledge. Indeed, scientists in laboratories throughout the world are continuing to probe the genes of various species, comparing the molecular genetics data with the fossil record and refining our knowledge of our species' history.

At the present stage of this never-ending research, the evidence suggests what to me is an awesome notion: like a biological Rosetta Stone or Dead Sea Scroll, our own DNA—an *Encyclopedia Brittanica*'s worth of information in every cell of the body—contains a record of the past which we are just now learning to read. This record, reflecting millions of years of genetic history, includes the relics of ancient genetic accidents that occurred before our apelike ancestors roamed the plains of Africa, relics that we now share with other descendants of the same ancestors—the great apes.

Acknowledgements

I am grateful to the many colleagues and friends who read earlier versions of this manuscript and made suggestions for improving clarity and balance. The comments of John Immerwahr, Jonathan Silver, and Mary Duncan were especially helpful.

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Letters to the Editor

It appears that Peter Hutcheson agrees with the creationists on their claim that a circular definition of *natural selection* renders evolution untestable ("Evolution and Testability," *Creation/Evolution* XVIII). I am not at all sure he is correct in this argument, but, if he is, he has failed to rescue evolution from its foes.

. . . Perhaps Hutcheson is not an engineer. Ask an engineer what makes good design and he will probably begin with various formulae and design rules . . . [the] result of standard engineering practice: if you don't use the rules, the bridge collapses or the airplane crashes. In other words, they are an expression of what mechanisms survive.

Consider, for example, Hutcheson's example of the peppered moth. Suppose an engineer were to design a moth that was required to survive on the gray bark of Manchester trees in the face of predatory birds. He might reason that . . . a black moth would soak up the sun better and thus be better prepared to . . . escape if a bird should come into view. So he designs such a moth and . . . although the moths do take off quickly, the birds approach unseen from behind and quickly gobble up the fruits of his labor before he is paid, so he goes back to the drawing board. This time he applies bird psychology and designs a moth to resemble the foul-tasting, gray-green tree frog, hoping that the birds will mistake it and leave the moths alone. The prototype survives much longer due to the good design principles employed in the choice of it color. The engineer is paid handsomely and goes home. Gray-green moths go into production under the careless supervision of the production engineer, who bungles the dye mix in the next batch (he left out the green). The moths survive as well or better, so the mistake is never noticed. Why is gray a good design and black a poor design? The gray moths survived and the black moths did not. After twenty years in an engineering profession, I can assure you that . . . if the product does not survive in the marketplace, the engineers don't get paid.

. . . So what if *natural selection* has a circular definition? So does I.Q.: "I.Q. is what intelligence tests measure." Hardly a more circular

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definition can be formulated. Yet, if I want to hire a junior engineer to work for me, I will certainly look for a high I.Q. (among other qualifications), because I have discovered that a high I.Q. score is positively correlated with good work in an engineering environment. In other words, the relationship between I.Q. (as measured) and work performance (measured in company profits) is testable and proven. Now that I am an assistant professor of computer science, I seek out grad students with high I.Q. scores to be research assistants, because I spend less effort explaining to them what I want done. I care not a whit that an I.Q. score is defined circularly, only that I want to work with high scores and not with low scores. I think that could be aptly called "survival of the fittest."

Thomas Pittman, Ph.D.
Kansas State University

Since the subject matter of *Creation/Evolution* is so profound—it is inevitably susceptible to mind-boggling esoteric complexity. What a delight, then, to find articles so lucid and accessible as those of Harold I. Brown ("Creationism and the Nature of Science") and Leon H. Albert ("'Scientific' Creationism as a Pseudoscience") in issue XVIII.

One remark of Albert's rang a bell for me. He noted that, in his debates with creationist Duane Gish, he was often subjected to Gish's wry remark that "whenever he came to debate scientists, he [Gish] wanted to talk about scientific facts while they wanted to talk philosophy." This is remarkably parallel to the findings of research into effective listening. When material is presented orally (as in a classroom lecture), some people understand it and retain it better than others. In attempting to explain why this is the case, researchers asked various test groups what they considered most important—what was it specifically that they were listening for. Over and over they got the same results. Those who responded "nothing in particular" scored about average in comprehension and retention; those who paid most attention to "ideas" scored above average. And those who scored below average *prided* themselves—this term appears in the research literature often enough to be remarkable—on their ability to listen for "facts."

It seems that Gish, in his insistence on dealing primarily with "facts" . . . has gauged his audience well. Evolutionists, on the other hand, would be well advised to avoid his trap and concentrate on the *ideas* involved.

Richard S. Russell

Editor's note: We have received many excellent letters discussing further Norman Geisler's design argument. Unfortunately, some were too lengthy to include here. Hopefully, space will permit publication in the next issue of Creation/Evolution.

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